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The Institute of Vitreous Enamellers
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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New Foundry Research Facilities

The new laboratories of the British Non-Ferrous Metals Research Association, which are being officially opened to-day by the Rt. Hon. Oliver Stanley, President of the Board of Trade, make a serious contribution to research facilities available to the foundry industry. Because of the interlocking effected through the Department of Scientific and Industrial Research, there is a guarantee that there will be the fullest co-operation with the British Cast Iron Research Association and the Steel Castings Research Committee. Moreover, a close contact with the Institute of British Foundrymen's appropriate Sub-Committees already exists. Indeed, the first exhibit we noticed during a visit to the new laboratories was a study of the casting of gun-metal-type test-bars, starting with the one tentatively specified by the Institute's committee. This is not deemed by the Association's staff to be entirely satisfactory, being liable to yield erratic and perhaps low results. A second method is the one which it is believed gives the truest appreciation of the worth of the metal, whilst a third is of a type stated to yield the best and highest test results. This work has been rendered possible by the installation of a very well equipped melting shop. The feature which made a major appeal to us is the existence of three 100-lb. (brass) capacity pit furnaces operating under entirely different, yet co-relatable and well-controlled, conditions. First and foremost there is a standard type of coke-fired furnace which should be capable of exactly reproducing industrial conditions. Next to it is an electric resistance furnace, which obviously permits of closely controlled atmospheres, whilst the third furnace is towns'-gas fired. We think that sufficient data are available to estimate from this the general effect of oil-firing crucible furnaces. If this be not the case, and it is thought worth while, there is still room for a fourth installation.

Almost since its inception, the Association has directed its attention to the production of sound ingots, especially in light alloys. Hansen and Slater's work is well known and highly appreciated in foundry circles. Now work is being undertaken involving controlled solidification so as to avoid excessive segregation. Thus the Association is well equipped to embark on an extension of these studies to embrace the general question of the running and gating of castings. To our mind, a piece of apparatus still needed is some sort of moulding machine capable of turning out a standard sand mould for test-pieces for both heavy and light non-ferrous metals, as the industry is not likely to be satisfied with a standard form of test-piece without a standardised method for preparation. It is insisted that the results obtained by two different artisans, each highly skilled, are too wide to engender full confidence.

The work which the Association is doing with the application of the spectroscope is both important and far-reaching. It is insufficiently recognised that this system of analysis can, and probably will in the future, render the chemical laboratory obsolete as a routine method for the control of metallic impurities in industry. Indeed, it is authoritatively stated that one iron foundry is so controlled in the United States, with speeds of operation unsurpassed by the most expert of industrial chemists. A piece of apparatus which attracted our attention was by Wheeler and Bone for the estimation of oxygen in non-ferrous alloys. It is limited at the moment to those having a melting point not materially higher than 1,200 deg. C. A small quantity is melted by electric resistance *in vacuo* and the oxygen is first converted to water, and the final figure read off on one leg of a mercury U tube.

The general level of the equipment is high, and in many cases of a specialised character, but it is obvious that wise restraint has been exercised in cases where the introduction of very expensive apparatus is concerned. Unless such machines can be fully utilised, the overall effect is inefficient duplication, as it is usually cheaper and generally quite easy to have tests carried out extramurally. In this connection it is not without interest to point to the researches the Association carry out in the bacteriological laboratories at South Kensington in connection with corrosion attributable to this cause. With the passage of time, the Association has centralised the major part of its research activities in Regnart Buildings, yet we think it would be unwise policy not to "farm out" a certain percentage, for by so doing a beneficial effect on the staff results, consequent upon wider academic contacts.

We are sure that we will be voicing the general opinion of the foundry industry when we congratulate the Association upon the commendable progress they have achieved, associating with this our very sincere good wishes for a successful future.

C

Spelter Duty Revision

BY "ONLOOKER."

After something like nine months of negotiations and discussions the authorities have at last made their official announcement about the revision of the import duty on foreign spelter, and from the details of the scheme it would appear that the only people likely to be pleased at the news are the zinc smelters of this country, who will receive a sum of 10s. in respect of every ton of spelter imported and sold by the overseas Empire producers in the United Kingdom. The foreign producer has to face up to a duty of 30s. per ton, which is about 10 per cent. of the L.M.E. price, but the British consumer is no better off if he buys Empire metal, for there is likely to be a premium on this equal to the duty. In order that this country's export trade may not suffer, the fabricators are to be allowed to claim at the rate of 17s. 6d. per ton in respect of the spelter in manufactured goods which they ship abroad, but it is stipulated that the cost of the zinc in such articles must be an important consideration. This phrase would appear to require some elucidation, and doubtless exporters will be advised in due course what they can and what they cannot do. One important point is, however, made clear, and that is the fact that claims for reimbursement may be made in respect of goods containing spelter of foreign origin as well as Empire brands.

Effect on Users

While no one would for a moment deny the wisdom of keeping this country's spelter industry on its feet, it would be idle to deny that the users of this metal feel distinctly aggrieved that they have been called upon to meet the entire cost of subsidising an essential war material. One has only to study the Board of Trade returns to discover that our exports of galvanised iron have very seriously declined during the past few years, and although that side of the industry will be no worse off owing to the drawback arrangement, it seems inevitable that the home section will be less able to stand up to competition from substitutes. The same can be said of the brass trade, and while it is obvious that the spelter consumers cannot plead a very serious handicap owing to the comparatively small increase in the price, the fact remains that, as a body of metal users, they are being called upon to face up to an annual bill running into thousands of pounds. Obviously, this has got to be passed on to the ultimate consumer, and it may perhaps prove to be the salvation of the present scheme that the market price of spelter is low by comparison with other non-ferrous metals, and that therefore its use is not so likely to be discouraged. Making all allowances for the need to keep home production going, and this it should be noted in passing is to be kept down to 60,000 tons per annum, the plan is ingenious and has much to recommend it, but it would have been fairer to the consumers of spelter if a plain subsidy had been given.

It is, of course, understood, now that the vexed duty question has at last been settled, that every effort will be made to resurrect the Zinc Cartel in order that world production will be regulated. Consumers of metals, who have in the past had a rather bitter experience of what this curtailment of output can mean to the price level, will be relieved to know that the producers undertake to safeguard the interests of the U.K. manufacturing consumers during the negotiations. Actually they are not likely to be subjected to any anxiety for some time to come, since it is admitted on all sides that the *pourparlers* regarding a cartel are likely to be prolonged and difficult, Germany being the chief stumbling block.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Cupola Control

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Referring to the very well written Paper by Mr. H. P. Hughes in the May 18 issue, there is one section with which I cannot agree, and that is the discussion of the effect of blast volume and its relation to the coke. From a long experience with varying blast pressures in the foundry in a production shop where the cupolas are always subordinated to the demands of the shop, we have found no untoward results from a very wide variation of blast pressure so long as certain limiting conditions are observed. These conditions are, first, that there must be sufficient velocity at the tuyeres to effect a reasonable penetration of the coke bed. It varies, for instance, from 2 ozs. pressure (750 c.f.m.) on a 21-in. cupola to about 8 ozs. (5,000 c.f.m.) on a 72-in. cupola. The upward limit seems to be where the cooling effect of the air is so much greater than the radiation from the inside of the cupola that the coke will not continue to burn at the tuyeres but blows dark. This is both a function of the blast temperature and the kind of coke. Modern by-product coke will withstand blast pressures of 30 to 35 ozs. in a 72-in. cupola without any untoward effect, especially with the warm blast cupolas in use at our plant. The blast temperatures are in the neighbourhood of 150 deg. C. Between these extremes of 8 ozs. and 35 ozs. (11,000 c.f.m.) the only effect that the blast has is on the rate of melting. No change is observed in the temperature of the iron or the analysis of the iron provided the bed has been adjusted to take care of it. It is, of course, foolish to expect to blow in a cupola at 18,000 cub. ft. per min. with the bed height set for 9,000. If, however, the bed has been set for 18,000 cub. ft. per min., the only ill-effect from blowing in at 9,000 will be a long period of time to wait for the iron and consequent waste of coke in the bed. The condition of the bed also governs what can be done with variation of the blast volume during a run. For instance, at Birmingham, Alabama, it is a fixed rule not to raise the pressure more than 2 ozs. at a time and watch the temperature of the stream, giving fully 15 mins. between rises. In case of a breakdown, though, it is not uncommon to drop the blast from 30 ozs. all the way to 8 ozs. and continue to run. Trouble will only arise when it is desired to come back. If the time of increase can be foreseen with sufficient accuracy to get the necessary extra coke on the bed at the time of raising it, no harm will be done.

To sum up, I would say that if proper consideration is given to the bed, no change in coke ratio is necessary for a change of blast volume within the limits above stated.

Yours, etc.,

JAMES T. MACKENZIE
(Chief Metallurgist, American Cast Iron Pipe Company).

Birmingham, Ala.
June 7, 1939.

(Continued from next column.)

to avoid such a recurrence. It is a brave effort, and it will be interesting to hear what the various hoteliers will find to replace it!

* * *

Another complaint has been registered this year, this time an unusual one. One regular attender of all the Congress functions complains that he finds himself still trying to lift the tails of his dress suit whenever he sits down at his office desk!

"MARKSMAN."

Random Shots

The social side of the International Congress must have seemed to many a veritable refresher course in history. Almost every day included a visit to some ancient building, every one of which is just steeped in the history of England, its kings and queens, and the powerful men of various eras. As for King Henry VIII, he positively dogged the ladies' footsteps (true to tradition, possibly). They met him at the Barbers' Hall, for it was he who gave the beautiful Royal Grace Cup of which the Worshipful Company of Barbers is so justly proud. They met him again at Hampton Court, for everyone knows how he "won" that great palace from Cardinal Wolsey, and they finally laid him to rest at Windsor Castle.

* * *

Life was no more serene or secure in those days than it is now. Although one did not hourly run the risk of being run over by motor cars or being blown up by the I.R.A., the offences against the law which demanded the death penalty were frighteningly slight. The Royal Grace Cup alone was responsible for the execution of at least five men, who were at various times involved in the theft of that coveted treasure. The Barbers' Company had, as one of its rights, permission to take four bodies every year from the public execution place at Tyburn (only a stone's throw from the Dorchester) for the purpose of dissection. They still preserve a gruesome story of how one of the bodies, just as the surgeon was brandishing his knife prior to cutting, suddenly called out "Don't! Don't!" The surgeon didn't, and the corpse was revived. Those worthy surgeons clubbed together to send the man out of the country, and the story goes that he eventually became a rich merchant and finally remembered his benefactors by presenting them with a beautiful Eastern screen.

* * *

The trip to Windsor, as predicted, had all the elements of excitement of the last half hour of a children's party . . . and indeed just as that affair comes to a climax in the final game of charades, so had this occasion its own charade, in which some of the more skittish members of the party played a game of waitresses!

* * *

The part of the river chosen for the boat excursion included some of the finest bits of scenery the Thames has to offer; Cliveden reach, just beyond Taplow, is famous as a beauty spot. Very few people have been the whole length of the river, for whereas many have "done" the river trips to the Nore Lighthouse, and nearly all have taken excursions up the river, even as far as Oxford, very few know anything of it beyond that point. In fact, it seems such an odd thing to do, that he who accomplishes the Thames in its entirety, needs must write a book about it. Of books, there is an account of the adventures of three men who followed the whole course of the river in a canoe, and there is also the story of an ardent walker and his daughter who walked the whole length of the Thames towpath. They started at Putney Bridge, and it took them a whole fortnight to complete the 158 miles of river right to its source in Gloucestershire.

* * *

Looking back at the International Congress issue of 1929, when London was again the "venue," "Marksman" finds he recorded a complaint against the unfailing regularity with which salmon was served up at official luncheons. Indeed there was such a surfeit of the stuff that some of the delegates must have paled at the sight of it for many months afterwards. This year Mr. Makemson is making a special effort

(Continued in previous column.)

The Post-Congress Tour

WORKS VISITS AND SOCIAL FUNCTIONS IN DERBY, MANCHESTER AND SCOTLAND

The visitors taking part in the Post-Congress Tour terminated their visit to Birmingham at mid-day on Tuesday, June 20, and proceeded to Derby by train, luncheon being taken *en route*. The party was met at Derby by Mr. and Mrs. C. W. Bigg and other members of the East Midlands Branch of the Institute of British Foundrymen, and a well-organised programme of works visits and social functions commenced immediately on arrival. The ladies inspected the famous Royal Crown Derby porcelain factory and afterwards visited Derby's beautiful parks, while the gentlemen were divided into three groups and visited respectively the works of Ley's Malleable Castings Company, Limited, Rolls Royce, Limited, and Qualcast, Limited. Later in the afternoon the whole party proceeded to Matlock, where accommodation for the night was provided at Smedley's Hydropathic and the Lilybank Hydropathic.

DINNER IN MATLOCK

A dinner was held in the evening at the New Bath Hotel, Matlock, Mr. R. H. Buckland (President of the East Midlands Branch) presiding. Among the principal guests were the Mayor and Mayoress of Derby, Alderman and Mrs. D. S. Butler.

Proposing the toast of "The Guests," MR. BUCKLAND said it gave him very great pleasure to extend to the visitors a very hearty welcome. He mentioned particularly Mr. Erdos (Secretary of the Hungarian Foundrymen's Association), Mr. W. B. Lake (President of the Institute of British Foundrymen), and Alderman and Mrs. Butler (Mayor and Mayoress of Derby). He welcomed also representatives of those firms who had kindly allowed their works to be opened and inspected by the delegates during their visit, and had also arranged the necessary hospitality. On behalf of the Branch, he thanked them most sincerely for the efforts made to assist them. It was his hope that the overseas delegates would take back to their own country a desire to continue to co-operate with the British people. Such functions as the Congress, he said, were calculated to have far-reaching effects in assisting to guarantee the peace of the world.

MR. R. ERDOS, responding to the toast, said they had been heartily welcomed by the members of the East Midlands Branch, and he thanked them all. He commented on the beauties of Derbyshire, and said that the visitors must thank all the foundry managements who had opened their doors to them. He wished every success to the Institute.

The MAYOR OF DERBY (Alderman D. S. Butler, J.P.) also responded to the toast. He spoke with pride of the prominent place which Derby occupied in the industrial life of the country, and expressed his delight to welcome the delegates to the district. He had himself travelled a good deal, he said, and had always met with the kindliest of receptions in other countries. He felt that conferences such as the visitors had attended helped to bring the people of different nations together and to promote a feeling of co-operation.

DR. M. BARIGOZZI and SIGNOR MARIO OLIVO (both of Italy) also responded, and spoke of the warm way in which the delegates had been welcomed.

Following the banquet the company was entertained by a musical programme.

On Wednesday, June 21, the delegates visited the works of Bamfords, Limited, of Uttoxeter; International Combustion, Limited, and the Stanton Ironworks Company, Limited. The delegates visiting the works of Bamfords, Limited, were entertained to luncheon at Oldfields Hall, the home of Capt. H. J. Bamford. The hosts were thanked by Mr. G. Lutoslawski of Poland and Mr. Erdos of Hungary. At the Stanton Works, Mr. E. J. Fox presided over a luncheon offered by the firm, and gave a number of interesting figures showing the very important place occupied by the Stanton Company in the European foundry industry.

The ladies made an all-day tour of Derbyshire, travelling from Matlock, *via* Rowsley, Chatsworth Park, Baslow, Calver, Hassop, Longstone, Monsal Dale, Wardlow Mires, Tideswell, Millers Dale, to Buxton for luncheon, and continued *via* Dovedale and Ashbourne.

All three parties united at Derby station in the evening and proceeded by train to Sheffield.

Arrival at Sheffield

The provision of the necessary hotel accommodation at Sheffield for a party which was one hundred per cent. larger than was anticipated a week or two previously, presented some difficulty to the organisers, especially as much of the available hotel accommodation in the city was booked on behalf of another conference. However, by using hotels in Matlock and Grindleford and with the aid of transport arrangements made by Mr. T. R. Walker, the heavy requirements of the visitors were met fully and satisfactorily. A real Yorkshire welcome was given by members of the Sheffield Branch and their ladies, and within an hour of arrival in the city the visitors assembled at the Grand Hotel, where they were entertained to dinner by the Branch. Mr. Malcolm Brown, the Branch-President, welcomed the guests and the Lord Mayor of Sheffield addressed them in French and in English. Mr. Rousseau, of France, editor of "La Fonderie Moderne," reciprocated the courtesy by replying for the visitors in what he described as his first speech in the English language.

After dinner, advantage was taken of the long light evening, and a drive was arranged through some of the beautiful scenery in the neighbourhood of the city.

Thursday, June 22, was devoted to works visits. Hadfields, Limited, entertained a party of visitors in the morning whilst the remainder accepted an invitation to visit the works of Firth-Vickers Stainless Steels, Limited. After luncheon, which was given by the Sheffield Branch of the Institute, visits were paid to the works of the English Steel Corporation, Limited, and Davy and United Engineering Company, Limited. The ladies of the party were entertained during the day by the ladies of the Sheffield Branch members. The Sheffield arrangements concluded in the early evening by departure by train for Manchester.

The Manchester headquarters were at the Midland Hotel, where an informal reception was given soon after arrival by members and ladies of the Lancashire Branch of the Institute of British Foundrymen, the guests being received by Mr. A. L. Key (President of the Branch) and Mrs. Key, and by Mr. H. V. Grundy (Chairman of the Reception Committee) and Mrs. Grundy.

VISITORS AND MEMBERS OF THE EAST MIDLANDS BRANCH PHOTOGRAPHED AT THE STANTON IRONWORKS COMPANY.

Visits were paid to two important engineering works on Friday, June 23, namely, to Mather & Platt in the morning and to the Metropolitan Vickers Electrical Company, Limited, in the afternoon, luncheon being given by the Lancashire Branch at the Grand Hotel between the two visits. The visit to Mather & Platt was under the guidance of Mr. Roberts, the works manager, and the Metropolitan Vickers visit was under the guidance of Mr. W. Jolley, Manager of Foundries. MR. ADLER-NISSEN, of Denmark, expressed the thanks of the visitors at the former works, and at the latter, thanks were tendered by MR. GUY, President of the South African Branch of the Institute, and by a lady, Miss Brons, of Holland.

The ladies of the party spent the day at Chester in company with the Lancashire ladies.

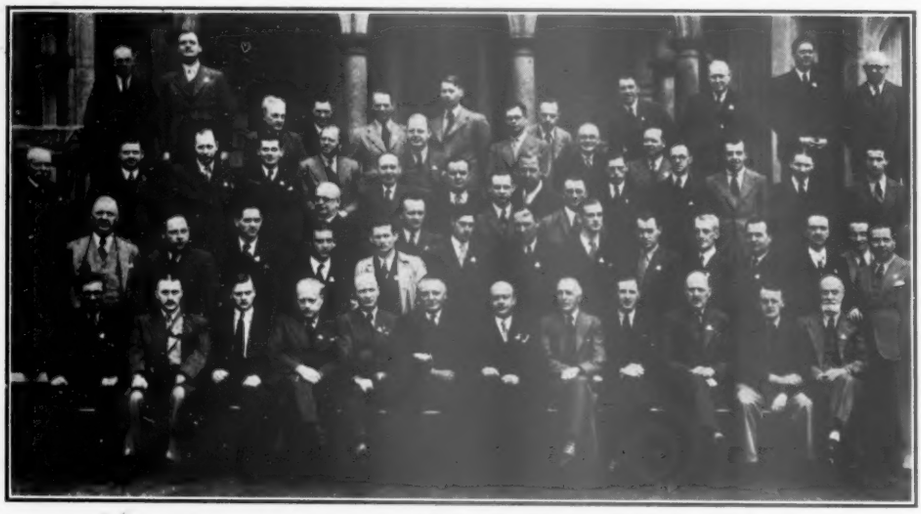
In the evening the party was entertained to dinner by the Lancashire Branch at the Midland Hotel. This gathering was notable for two reasons; it coincided with the seventieth birthday of the President of the Institute, Mr. W. B. Lake, and as the first part of the post-

Congress tour terminated on the following day, it was a farewell gathering for many of the overseas visitors. Mr. A. L. Key, President of the Branch, presided.

SPEECHES AT MANCHESTER DINNER

Among the English guests invited were Mr. A. C. Dean (President, Manchester Association of Engineers), Mr. E. Longden, A.M.I.Mech.E. (representing Craven Bros. (Manchester), Limited), and Prof. F. C. Thompson, M.Sc., D.Met. (Principal of the Department of Metallurgy, Victoria University, Manchester).

The arrangements for the dinner were in the hands of a reception committee consisting of Mr. H. V. Grundy (chairman); Mr. A. L. Key (President, Lancashire Branch); Mr. W. Holland and Mr. E. J. L. Howard (Senior and Junior Vice-Presidents); Mr. R. A. Jones (member of National Committee for the International Foundry Congress); Mr. R. A. Miles (member, Lancashire Branch Council); Mr. T. Makemson (Secretary of the Institute and of the International Committee), and Mr. J. E. Cooke (Hon. Secretary of Lancashire Reception Committee).



VISITORS AT THE UTTOXETER WORKS OF BAMFORDS, LIMITED.

"Our Guests"

The toast of "Our Guests" was proposed by MR. R. GREENWOOD (managing director of Craven Bros. (Manchester), Limited), who said it was very gratifying indeed to the Lancashire Branch of the Institute of British Foundrymen to have so many important visitors to the International Foundry Congress making a journey to such a large industrial and manufacturing but perhaps not very beautiful city as Manchester. The Reception Committee had given him a very clear warning to the effect that anything he could find to say in proposing the toast should be brief and light in character. Therefore, he had to ponder upon how to produce a few flowery, flowing figures of speech light in character, and although Mr. Greenwood professed that this was a task which he had found very difficult, nevertheless his early remarks were of a delightfully jocular and humorous nature. For instance, he spoke of the conscious humorist in the foundry—a man who rang up the machine-tool engineer whom he had supplied with castings, and who for some time had been complaining about their quality. He did not inform the engineer who was speaking on the 'phone, but said that he wanted a lathe, and then added, "I am not going to send you the inquiry because the castings that you supply, so I have been told, are just about the worst in the world." The engineer lost his temper straightaway and said the castings used by his firm were the best it was possible to obtain. Then said the foundryman: "I'm the fellow who supplies you with them, and I'm very glad to find that all the complaints you have been making recently about them are a mistake."

Mr. Lake, in his message in THE FOUNDRY TRADE JOURNAL, had directed attention to the beneficial results achieved by such Congresses as that of the foundrymen. Everything that Mr. Lake had said could be heartily endorsed. Men who were studying the problems of the foundry trade, attending technical meetings month by month over a long period of years, both at home and abroad, for the purpose of exchanging the technique of their craft, were performing valuable pioneer work and helping to push forward the cumulative knowledge of the world. Among such people were their overseas guests that night. He did not wish to encroach upon other toasts to be proposed, but he might be permitted to say that the good ship "Endeavour" voyaging in the sea of science and engineering during the past 40 years, piloted by foundrymen, had carried its full weight of responsibility. The fields of research and production in science and engineering would have been very seriously neglected if the foundryman and the metallurgist had not been receptive to new knowledge, and speaking for themselves particularly if the foundryman had not kept in time and in step in his own domain.

The engineer was now something of a foundryman and appreciated the difficulties of foundry work more than he did some years ago. He was quite sure they could expect the engineer, the foundryman, the metallurgist and the scientist to continue the march forward to greater triumphs in the future.

In proposing the toast he wished to express the hope that the shadows which were at present cast over the relations of the nations would soon be dissolved in the light of truth and a greater knowledge of each other. Such international gatherings as theirs did a great deal to dispel doubts and misunderstandings. It was to be hoped they would be permitted to carry on their meetings year by year, that they would be able to follow their peaceful avocations, and that the only wars which would be conducted would be in the form of rivalry in regard to competition in world markets.

He coupled the toast with the names of Mr. Y. Granstrom (Sweden); Mr. F. B. Bahker (Holland), and Mr. F. C. Krebs (Denmark).

The toast was amplified by MR. W. JOLLEY (Metropolitan-Vickers Electrical Company, Limited) on behalf of the Manchester firms who received the visitors. He welcomed the opportunity of meeting all the overseas ladies and gentlemen, he said, because it enabled him to renew contacts with the countries whose hospitality it had been his privilege to accept upon many occasions. He had attended a number of international gatherings and congresses, in America, France, Germany, Italy, and Belgium. He retained very pleasant memories of the kindnesses and the help that had been given to him when visiting those countries, and he had been assured that the results of those visits had developed a feeling and an understanding which would be maintained for very many years. It was the hope of all the British members that the overseas visitors had thoroughly enjoyed their visit and would continue to do so throughout their stay in Britain.

On behalf of each of the three firms visited, he wished to state how happy they had been because of the opportunity of receiving the overseas visitors, and to express the hope that they would return to their respective countries with very pleasant thoughts of their visit, and that it would prove of advantage to them all.

Replies on Behalf of Visitors

MR. Y. GRANSTROM (Sweden), in responding to the toast on behalf of the overseas visitors, very sincerely thanked both Mr. Greenwood and Mr. Jolley for their kind words of welcome. He also wished to express their most sincere thanks to the Lancashire Branch for the pleasure that had been accorded to them during the visit, and for the dinner given in their honour. The name of Manchester was well known, and he did not believe there was one of the overseas visitors who did not regard it as one of the most famous industrial centres of the world. During their works visits at Manchester they had seen the most up-to-date equipment, and the visit had been one of the most interesting they had made during the trip. They had also been taken to view some of the lovely scenery in the neighbourhood. Many of them were paying a visit to England for the first time, and all of them would return to their own homes and their own foundry businesses with remembrance of the kindness and hospitality of the great British people. The overseas visitors understood very well all that had been done for them and all the trouble that had been taken to make the trip the success it had been. Their feelings of gratitude went out to the Institute of British Foundrymen, to their President, Mr. Lake, and to the Secretary, Mr. Makemson, and all others who had helped to make their stay in England such a happy one.

MR. F. B. BAHKER (Holland) also responded to the toast, stating that the pleasure of the visit would never be forgotten by any of them. The hospitality and friendliness which had been bestowed upon them all had indeed overwhelmed them. If what they had heard in London was correct, namely, that the 1941 World Congress would be held in Holland, then the Dutch representatives hoped to meet them all again, and would make an effort to return at any rate some part of the hospitality and friendliness they had enjoyed in England.

MR. F. C. KREBS (Denmark), responding on behalf of the Danish representatives, referred to the many interesting Papers which had been read in London, and which he was convinced they would all study very closely upon their return to their own home countries. They were deeply indebted to the firms who had permitted them to inspect their works, and for providing them all with much food for thought.

The toast of "The Institute of British Foundrymen," coupled with "The Lancashire Branch," was then proposed by SIR FREDERICK J. WEST, C.B.E., J.P. (Chairman of the Manchester Ship Canal Company). He said that Manchester was an exceedingly interesting place from the point of view of its industrial activities, and particularly so on the engineering side. People usually associated Manchester as being the hub or the centre of the cotton or textile industry. Very few people in this country, and

indeed in Manchester, were aware of the fact that there was in Manchester one of the greatest engineering centres of England. There were employed, within 10 or 15 miles radius of Manchester, more engineering workers in engineering factories than were employed in the cotton factories. This was an indication of Manchester's development and great activity in the engineering industry. As a Manchester engineer he could claim that the city was now producing some of the finest products in its foundries which could be produced in the country. He was interested to see the other day some castings in connection with one of the Manchester Ship Canal bridges, which had been in operation for 45 years, *i.e.*, since 1894. They had only just reached the stage at which they required renewal. Speaking as an engineer, in his opinion, this was much too long a time for any engineering product to last. He was a great believer in having a change every 20 years.

During the past 31 years the Institute had made wonderful progress, and in regard to the foundry work generally they were all alive to the necessity for extremely close association between the designer and the pattern shop, and between the pattern shop and the foundry.

MR. W. B. LAKE (President of the Institute), responding to the toast, remarked it was an additional pleasure to hear words of commendation from one who had such a thorough grasp of foundry practice as Sir Frederick West. He was particularly proud to be President of the Institute of British Foundrymen, because it was a really live Institute, with an energetic Council and series of Committees. He wished to thank the members of the Branch for the very efficient and successful way in which they had organised the local programme and attended to the comfort of the visitors.

Coming to the sad part, as it might be termed, of the few words he intended to say, unfortunately a very large number of their visitors would be leaving on the morrow. He could assure them that their British friends had enjoyed their company very much, and that they were very sorry indeed to lose them. British people desired to live as friends with all people, and it was their highest ambition to live in peace and in amity with all nations in a world which was ruled by truth and justice. (Cheers.)

MR. A. L. KEY (President, Lancashire Branch), also responding to the toast, remarked that the Institute was not merely an Institute of technology—there was something more vital than that about it—but it was also a source of inspiration.

Presentation to Mr. Lake

Mr. Key then explained that the members of the Lancashire Branch wished to celebrate the important date in Mr. Lake's life which occurred that day, and on behalf of the Branch he presented to Mr. Lake a silver tankard.

In reply, MR. LAKE said that he was almost overwhelmed by the kind expressions of goodwill and by the congratulations he had received that day. His co-directors and his staff and workpeople had sent him a special message by one of his fellow-directors and were preparing a presentation to him, he had received a wonderful present from the Past-Presidents of the Institute and now came this very welcome gift from the Lancashire Branch.

The morning of Saturday, June 24, was spent at the works of Craven Bros. (Manchester), Limited, under the guidance of Mr. Greenwood and Mr. E. Longden, the foundry manager, and the party was afterwards entertained to lunch by Mr. Greenwood and the company. In thanking the company for their hospitality, DR. PAROW-SOUCHON, of Germany, expressed the thanks and appreciation of those visitors who were leaving that day to Mr. Tom Makemson for his help to them in many directions.

During the afternoon there were many goodbyes and about sixty of the visitors departed for their homes in many countries. The remainder were reinforced by a few additional tourists, and departed for Windermere to the number of thirty-six for the week-end, thus commencing the second part of the post-Congress tour.

A SCOTTISH WELCOME

Sunday, June 25, was spent quietly at Windermere and in the evening the party proceeded by road through the Lake District to Keswick and entrained for Glasgow. The Scottish part of the tour commenced with a Scottish welcome before Scotland was reached, Mr. H. Winterton, Past-President of the Institute, and Mr. J. M. Primrose boarding the train at Carlisle. They immediately converted a portion of one of the dining cars into an office and were soon busy issuing programmes and tickets for the Scottish arrangements.

A very delightful day was spent last Monday. The visitors, together with a number of members of the Scottish Branch and their ladies, numbering altogether about 190 people, spent the day on the Firth of Clyde, the steamer "Caledonia" having been chartered for the occasion. SIR JAMES LITHGOW, President of the Reception Committee, gave a short address of welcome from the paddle box of the steamer, and MR. POLCZARSKI and MR. HARASOWISKI, both of Poland, responded. The steamer passed down the Clyde past the shipyards and past the gigantic new "Queen Elizabeth" into the Firth of Clyde. Loch Long was traversed, the steamer then returned along Loch Long and proceeded through the Kyles of Bute to Loch Ranza in Arran. The journey then proceeded between the Cumbraes, and after a visit to the Holy Loch, it terminated at Gourock whence the party returned to Glasgow by special train.

A delightful informal function took place in a private room of the Central Hotel, Glasgow, on Monday evening. MR. SISSENER, of Norway, explained that the overseas visitors had learned that Mr. Lake would have to leave the party on Wednesday, and they were desirous of giving him a token of their esteem and affection as a souvenir of their journey and as an expression of their gratitude for his many kindnesses. On their behalf he then presented Mr. Lake with a silver entrée dish, and a list of signatures of all the party participating in the second week of the tour.

MR. LAKE, who was deeply moved, said that he had received so many gifts and so much kindness that he felt that mere thanks were inadequate to express his feelings. The tour had been one of the pleasantest experiences of his life, and he and the members of the Institute were delighted to know it had given pleasure to their guests.

On Tuesday there was a series of works visits in Glasgow and a reception by the Civic Authorities. Wednesday was devoted to sightseeing in Edinburgh. To-day (Thursday) and to-morrow will be spent in Newcastle-upon-Tyne, whence the party will return to London.

ADDITIONAL REGISTRATIONS

In addition to the delegates to the International Foundry Congress in London whose names have already been published, the following members of the Polish Association registered as participants of the Congress, though they were unable to be present in person:—S. Ambrozewicz; I. Banachiewicz; S. Bratkowski; A. Erbe; W. Erbe; O. Fajfel; K. Fangor; T. Golebiowski; W. Gurycki; A. Hess; J. Holtorp; S. Jarkowski; G. John; S. Jussewicz; S. Langiewicz; E. Macher; J. Milker; A. Sledzinski; S. Szczawinski; J. Zybert; J. Baurski; J. Gosiewski; D. Niemcewicz; W. Wieloglowski; K. Witwicki; C. Kalata; J. Kozarzewski; A. Dabkowski, and E. Kolomyjski.

Competition for Apprentice Moulders in Sheffield

Last year the Sheffield Branch of the Institute of British Foundrymen arranged a competition for apprentice patternmakers. The success of this competition, an account of which was given in the JOURNAL for December 29, 1938, encouraged the Sheffield Council to arrange during the current year a similar competition for apprentice moulders working in Sheffield and district. This second competition was held on Saturday, May 20. It was decided to divide the competitors into two classes, the first being apprentices for steel moulding and the second apprentices for cast iron moulding. The same pattern was used for both classes, this consisting of a built-up wood pattern with loose pieces, of a bracket with bosses. The age of the competitors was from 16 to 20 years, and an allowance for age was made in the case of competitors under 18 by simplifying the pattern. In all, 27 competitors presented themselves in the cast-iron division, and 26 for steel moulding. Most of these were employed in Sheffield, the remainder coming from Chapeltown, Chesterfield and other outlying districts.

In the steel section the competition was held in the foundry of English Steel Corporation and in the iron section in the foundry at Sheffield University, both of these being very kindly placed at the disposal of the Council by the authorities concerned. Competitors were provided with backing sand, facing sand, moulding boxes and all necessary materials, tools including rammer, bellows, etc., and were instructed to bring with them other tools required for finishing the mould. The time allowed was 4½ hours for the steel moulders, and 4 hours for the cast-iron moulders. Competitors were informed that marks would be awarded for method of moulding, workmanship and time taken. It was thus necessary to arrange for Stewards to watch the work of the competitors during the competition, and this duty was efficiently carried out by volunteers consisting of managers and foremen of local foundries.

At the conclusion of the competitors' work, all the moulds were filled with steel and cast iron respectively and left until cold; they were then examined by the judges. Three prizes of £3, £2, and £1 were very kindly provided by Prof. Andrew, the President of the Sheffield Branch, similar prizes being awarded in both the steel and the cast-iron sections. The prizewinners were as follow:—

Steel division.—First prize, T. Chapman (aged 18 years 4 months, and working at Edgar Allen & Company, Limited); second prize, J. Hanneman (aged 16 years 11 months, and working at Hadfields, Limited); third prize, A. Thompson (aged 19 years, and working at Edgar Allen & Company, Limited).

Cast-Iron division.—First prize, L. Shaw (aged 19 years 10 months, and working at Newton, Chambers & Company Limited); second prize, K. Batty (aged 15 years 11 months, and working at C. & J. Hampton, Limited); third prize, L. Liptrot (aged 17 years 6 months, and working at Newton Chambers & Company, Limited).

The competition proved most interesting and instructive to the judges and stewards as well as to the competitors, and it has been decided to hold a meeting in November next to which all the competitors will be invited, and at which a discussion will take place covering all aspects of the competition.

ROBSON REFRACTORIES, LIMITED, of 47, Coniscliffe Road, Darlington, have concluded an arrangement with Signor Mario Olivo for the sale in this country of the products of Impianti Fonderie Olivo, Milan.

International Foundry Congress

Synthetic Moulding Sands and Core-Shop Control

DISCUSSION AT FIRST TECHNICAL SESSION

At the first Technical Session of the International Foundry Congress held on June 13, at the Dorchester Hotel, the President (Mr. W. B. Lake) presiding, the two Papers, "Bonding Clays and the Properties of Synthetic Moulding Sands" by DR. G. H. PIPER and "Core Shop Control" by Mr. J. J. SHEEHAN, were discussed conjointly.

Moisture Content Control in Practice

DR. J. G. A. SKERL said the subject matter of Dr. Piper's Paper was well known to him, as a member of the Sands Committee of the British Cast Iron Research Association, and also because the work was initiated when he was a member of the staff. He could vouch for the very great importance of some of the conclusions which Dr. Piper had drawn, especially those dealing with the more theoretical side of the conditions of clay necessary to bond a silica sand in the foundry. Unfortunately, it had not been possible to carry out the very full scheme of research that he had thought would be necessary. The work described in the Paper dealt with the laboratory side, but we really wanted the practical results in the foundry, because quite frankly in the foundry one could not deal with some of the moisture contents that were given in the Paper. With the 3 and 5 per cent. mixtures, the optimum strength was attained at anything in the region down to 1.5 per cent. of moisture and such figures were impossible of attainment under practical conditions. In general one found in foundries, even when dealing with synthetic sands, that the moisture content must be in the region of approximately 4 per cent. That meant that it was necessary to add a large excess of the bonding medium. A synthetic sand as used in the foundry did not contain 3 or 5 per cent. bentonite or other bonding material, but usually contained from 8 to 12 per cent., such contents being necessary to take care of the water which had to be added to make the material usable in the foundry. Even so, when using synthetic sands it was often found necessary to hasten in casting the moulds because of the tendency to drying off. From his experience he felt certain that under practical conditions the benefit arising from the use of bentonite could not be shown up quite so greatly as in laboratory work. In the Paper bentonite was shown to give very superior results, but under actual foundry conditions that superiority was not maintained to so great an extent.

Influence of Coal-Dust Ash

Commenting on a statement in the Paper that where coal dust was added, the refractoriness of the bonding clay was of minor importance as compared with that of the coal ash accumulating, and that a typical coal dust of British origin might give 5 per cent. of ash, the fusion point and analysis being given, Dr. Skerl agreed, of course, that coal ash would accumulate, but he pointed out that if 5 per cent. of coal dust containing 5 per cent. of ash were added, the amount of ash present was very small. At the same time, there would be 3 or 5 or 10 per cent. of bentonite present; the bentonite would always be the preponderating factor, and since bentonite was shown in the Paper to have as low a refractoriness as the coal dust, he hardly agreed with the statement that the refractoriness of bonding clay was of minor importance in comparison with that of the coal ash.

Expressing his very greatest admiration of Mr. Sheehan's Paper, he said he had read it three times already and could find nothing in it which he could criticise, because it dealt with facts only. Commenting, however, upon the point made by Mr. Sheehan that the use of sand which consisted only of rounded grains had resulted in chaos in the foundry, he said he would like to know the name of that particular sand, because such knowledge would give one rather a greater insight into the Paper and into the difficulties which had been surmounted in the method described by Mr. Sheehan. The Paper was the finest he knew of on the subject of core shop control.

Tar Oil Films

MR. BEN HIRD, having congratulated Dr. Piper on his valuable Paper, referred particularly to the reference to coal dust giving added strength to the dry compression, and asked if Dr. Piper had found that the coal dust also gave added strength in the green stage, after it had been used for casting five or six times. He also asked for Dr. Piper's opinion on the usefulness of the clay bond on the grains of an ordinary sand, say a red sand such as the Bromsgrove sand, after it had been coated by the carbon film derived from the coal. When a grain of sand had been turned from a red to a black grain, obviously it had acquired a carbon coating, and he asked whether that destroyed entirely the bond of the clay.

Bentonite and Moisture Content

MR. R. J. RICHARDSON (Pontypridd) said that having read some data on bentonite mixtures, and having attempted to use them in the foundry, at the moisture contents suggested by one of the sellers, and indicated by laboratory tests, he found them absolutely useless for moulding purposes, the percentage of moisture being so low that the sands were too dry to bond by the time they reached the moulding machines.

Recently, before he had known that Dr. Piper was presenting a Paper, he made tests on Dorset clay, and found them helpful, because when using Dorset clay, owing to the amount of clay and the necessary water being considerably greater than when using bentonite, it was found the sands did not dry up so quickly, and could be used at the suggested moisture contents shown in Dr. Piper's Paper. One of the principal difficulties encountered when using Dorset clay was to add it in such a manner that it was distributed equally throughout the mass. An operator had been told to mix a batch by rule of thumb methods, and produced a mixture which appeared to feel very good, but on testing it was found to contain 45 per cent. of clay, 10 per cent. of which was distributed, the other 35 per cent. being in small lump form. During the past week he had tried adding the clay in a form of slurry, and he asked the views of others on this question.

Whereas bentonite had the advantage that it was sold and could be added in a dry dust form, the natural clays could not be obtained in this form, and it was rather difficult in foundry practice to dry these clays and prepare them by ball milling to make them suitable for adding correctly for sand mixing.

The same sort of problem of unequal distribution had arisen in Mr. Sheehan's Paper, in which reference is made to the advantage of silica flour. He asked by what method Mr. Sheehan was able to ensure that the silica flour was suspended uniformly. When spraying silica flour water was used, and there was a danger of the silica flour being left at the bottom of the containers.

Sand Control in Mechanised Foundries

MR. F. J. COOK (Past-President, Institute of British Foundrymen) said the fact mentioned by Dr. Piper, that bentonite had very good bonding power, sometimes led foundrymen astray. One was rather tempted to use bentonite in excess because of its great green strength bonding power, but owing to its increased *dry bond* strength over Colbond it may give trouble in mechanised plants. On one occasion he had experienced trouble in a mechanised plant in which a bentonite mixture was used; it was found that at the knock-out half the sand came through the riddle unbroken, due to the great dry strength attained when the metal was poured into the mould. Therefore, it had been necessary to resort to Colbond, which was as strong in green sand and much weaker in dry strength, but which gave no trouble in that respect. Practically all the sand then passed through the riddle, there being very little discard, whereas, when using bentonite, with its extra dry strength bonding power, most of the sand came through in the discard.

Moisture Absorption Tests

MR. A. TIPPER, M.Sc.(Eng.), asked Dr. Piper whether, in his tests for determining the bonding strength of clays, the method of measuring the moisture absorption was found to be a practical test for the ordinary laboratory. It would be very convenient, he said, if it were possible to adapt one or two simple tests which would show immediately whether a clay was useless or very good, and the moisture absorption test in particular was mentioned as giving results which compared favourably with the dry strength and green strength figures, and placed clays in the same order. He asked for more information concerning the details of that test, and whether it could be carried out easily under comparable conditions.

Another question was whether it was possible to effect the bonding of red sands synthetically. Several people in practice had actually added ferric hydroxide, and claimed that they had derived benefit from it. He wondered whether any further tests had been made on the addition of ferric hydroxide or the production of a type of red mineral bonding matter.

The Paper by Mr. Sheehan was another extraordinarily fine example of the application of scientific principles in the foundry, and one could say definitely that it was the best example to date of the application of those principles to the core shop. The success achieved by Mr. Sheehan under conditions which presumably were really difficult was sufficient to encourage others in the same direction. In the past some of the aspects of core making which were dealt with in the Paper, such as the effect of grain size on permeability and surface finish, had been realised, but they had been tackled more or less by methods of trial and error, and not on fundamental principles.

Conversion to B.S. Units

There was obviously the possibility of adopting those principles, not only for core sands but for moulding sands in general, and particularly as applied to synthetic sand practice (he referred particularly to the calculation of the fitting-in of grain size and its effect on permeability, expansion characteristics and other properties). It was worth mentioning, too, that, although the grouping into four classes of grain size was given by Mr. Sheehan, based on the I.M.M. screen size, it could also apply in just the same way to our other British Standard screen sizes. In this one had to take the 30 mesh as the unit dimension of the screen. Assuming D to be 0.50 mm. (B.S.S. sieve No. 30), then 72 corresponded to 2/5D, 150 corresponded to 1/5D and 300 corresponded to 1/10D.

The Fitting-In Theory Applied

He asked Mr. Sheehan whether in his opinion his statement regarding the application of those principles to irregular shaped grains, as distinct from spheres, really did hold good in practice, as a generality, because all our natural deposits consisted of irregular or sub-angular grains or fragments, and if those fragments did obey the same law of fitting in as did round spheres, then the industry could go ahead and say that every sand would obey that law in a general way, and it could start to develop mixtures of particular types of sand which would give either the maximum fitting in or the minimum fitting in.

Considering one or two actual mixtures in that connection, he said he had found, for instance, that a mixture of Southport sea sand (containing 45 and 55 per cent. respectively of groups I and II) and Ryarsh silica sand (containing 2.5, 71 and 26 per cent. respectively of groups I, II, and III), if mixed in the proportion of 2 parts of Southport sea sand to 1 part of Ryarsh silica sand, gave a very considerable degree of fitting in, and the permeability, which was 140 in the case of the Southport sand, was reduced to 60 in the mixture.

Core Baking Control

Very wisely, Mr. Sheehan had not attempted to deal with all aspects of control in his paper. One regretted particularly, however, that he had not dealt with core baking control, which had a very definite bearing on conditions in the foundry. The troublesome fumes occurring during casting were largely accentuated by incomplete baking and the determination of volatile matter or gas content of dry cores afforded a useful guide to correct baking conditions. Fortunately, conditions in the mould usually allowed a large factor of safety, and it was probably for that reason that Mr. Sheehan had found it unnecessary to adopt any strict control of the baking. Local conditions would naturally make all the difference and must always determine the exact baking procedure.

Congratulating Mr. Sheehan particularly on his control of air drying of core sand mixtures, he said it was a very difficult matter to tackle successfully in a mechanised core shop. The problem, he believed, was one of controlling the loss of moisture. Drying out was simply a case of loss of moisture from the mixture, and one could adopt several methods to prevent it. For example, one could place the mixture in a completely enclosed box, cover it over and keep the sand for weeks in reasonably good condition. That might not be practical in Mr. Sheehan's works but it might at least be considered as an alternative to other methods. One disadvantage of adopting a chemical method of preventing drying out was the difficulty of ensuring sufficient drying out of the prepared core to prevent sagging. If the mixture did not air-dry reasonably fast, there was every chance of some cores distorting or squatting on the conveyor; or conversely, if it did dry out reasonably fast, then considerable core sand might have to be wasted. If one avoided drying out on the first conveyor, before the core was made, then the rate of drying might not be sufficient after the core was made to prevent some slight sagging or distortion.

Quantity of Binder and Grain Size

He did not agree with Mr. Sheehan that the proportion of binder required was proportional to the grain size of the sand used. Other factors besides the surface area of the sand came into that question. Probably it applied where one used a thin binder, such as a fluid oil, which gave a maximum distribution; but in many mixtures there was not complete distribution, and many factors other than surface area of the grains affected the bond obtained with a definite proportion of compound. It was more important to consider the conditions of mixing and possibly the additions of such substances as water or some other agent which would aid the distribution, than to consider merely the percentage of material added.

The Necessity for Fineness in Clays

MR. W. J. REES (Sheffield University) confirmed, as the result of tests on a completely different series of clays, the relationship found by Dr. Piper between the moisture absorption and the bonding power. In his laboratory, he had made the test on a series of more than 20 clays from different parts of the country—ball clays, kaolins and various fireclays—and had found the relationship to be quite important. He saw no difficulty at all in translating it into a laboratory test, provided the conditions of exposure were maintained absolutely constant. Given that condition, he was of opinion that it could be made an exceedingly useful ancillary method for evaluating bond clays for synthetic sand mixtures.

An important consideration with regard to the use of clays in synthetic sand mixtures was that they must be finely ground initially. Although Dr. Piper had referred to the use of clays ground to pass 30 mesh, Mr. Rees expressed the view that that was not sufficiently fine to ensure that the greatest efficiency would be obtained from the sand. The clays really needed pulverising so that at any rate more than half would pass 50 or 60 mesh. Their distribution was aided thereby and the efficiency of bonding was very definitely increased.

Distribution of Slurry

Commenting upon Mr. Richardson's reference to the possibility of adding the clay to the sand as a slurry or slip, he agreed that that did aid very much the distribution of the clay. The only difficulty was that when a slip was used it was by no means easy to control the proportion of water. If one added sufficient slip to give the required content of clay, one would, at the same time, add too much water. However, there were possibilities in that direction in the use of a de-flocculating slip, produced by adding to the slip a trace of alkali, so that the slip could be made to contain almost as much clay as a lump of solid plastic clay of corresponding size. The clay added in that form was distributed very easily throughout the mass of sand and gave a very excellent mixture.

Discussing the relationship between the green strength and the dry strength, discussed in Dr. Piper's Paper, he said the figures in the Paper showed that, comparing, say, bentonite with ball clay, the optimum green strengths were much the same, but the dry strength of the bentonite was very much higher. That was of great interest, and so far as he was aware there was no complete explanation of that difference. One noted this difference with a number of clays, and it is probably connected with the ultimate grain size and colloid content, but if one could obtain a complete answer to the question as to why that considerable increase in dry strength was obtained, with little or no increase in the green strength, a great step forward would be made in the study of synthetic sands.

The Paper by Mr. Sheehan, he said, must be of the very greatest use to the practical foundryman; and it will also be of very great service to those engaged more with the theoretical aspects of foundry sands. He congratulated Mr. Sheehan upon the very lucid form in which he had presented the Paper.

DR. PIPER'S REPLY

DR. PIPER, replying to Dr. Skerl, said that one reason for the low moisture content of the synthetic moulding sands given in Tables I and II was the fact that a silica sand containing very little silt was used. If the sand used had contained a greater silt proportion, there was no doubt that a greater amount of water would have been required for the synthetic moulding sand.

The results in the Paper were obtained from a research by the British Cast Iron Research Association and it had not been possible to include all the results. In particular, there was one in which an old moulding sand was rebonded with the bonding clays to a moisture content of about 5 or 6 per cent., which was more in agreement with what would be done actually in the foundry, and it was found that the same results held true, that the bentonite gave twice as much increase of bonding power as Colbond.

The difficulty about carrying out tests in the foundry was that in general coal dust was added at the same time, and as Mr. Hird had pointed out, the addition of coal dust increased the dry strength as well as the green strength. That result was found in the durability trial. If extensive comparisons of the bonding clays could be made in the foundry, it would be necessary to exercise a very careful control of the amount of coal dust in order to see that the increased bond produced by coal dust additions was the same in each case.

Commenting on Mr. Rees' confirmation of the results of the water absorption tests, and the possibility of modifying the tests to render them convenient for assessing the bonding clays, he said that in the work described in the Paper on clay absorption, *i.e.*, the amount of water absorption by the clay under atmospheric moisture conditions, the clays were allowed to absorb water and were kept in an enclosed space for about a week to enable them to reach equilibrium. There was no doubt that the test could be made into a very convenient practical test of bonding clays.

The particle size of the ground clays was important. The fireclays were ground to pass a 30 mesh sieve actually, although he had not made a sieve analysis of the pulverised clay. There was no doubt that the clay used in the tests was considerably finer than 30 mesh.

The bond obtained by adding the fireclay to the sand in the form of a slip with water was not appreciably different, however, than when the clay was added as a dry powder and water added during milling.

Agreeing with Mr. Rees that there was a great deal of difference between the green and dry strengths of the mixtures, he said he did not know the cause of that exactly, for he had not investigated it; but possibly it was due to the dry strength being dependent in some way on the grip between the clay and the sand grains.

MR. SHEEHAN'S REPLY

MR. SHEEHAN, replying to the discussion, said it would be invidious to give the name of the rounded-grain sand which had caused trouble in use, but he assured Dr. Skerl that he could select several sands which would give rise to such trouble. That was the result of using any sand falling within the grouping indicated in the Paper, and the more narrowly it came within that grouping the greater the trouble that would be experienced. The coarser sand would give more trouble, of course, in the production of fins than would a finer one, but even the finer one would give considerable trouble.

Replying to Mr. Richardson, he said that silica flour was very conveniently added in the powdered form, and there was no difficulty nowadays in obtaining silica flour suitably graded. Recently he had not found it necessary to add the flour to the moulding sand, although it was American practice to do so. He also used it very successfully as a wash, more successfully than he had been able to use a plumbago wash, for the reasons given in the Paper. It was kept in suspension by following the formula given in the section of the Paper headed "Washes," *i.e.*, silica flour 21 galls., Colbond 9 galls., water 36 galls. and dextrin 4 pints. It was regulated to a suitable viscosity, dependent upon how it was applied. There had been a little trouble in getting a suitable medium in which to suspend silica flour, but once the viscometer came to be used for control, the matter became compara-

tively simple. He and his colleagues did not use the viscometer very extensively, because once they had obtained their control by that method, the Beaumé gravity was sufficient to keep it within usable limits.

Binder Quantities Defined

With regard to Mr. Tipper's criticism concerning the statement that the proportion of binder used was determined by the size of the grain, he said that possibly that should have been qualified by stating that it depended, of course, also on the type of binder used. The binders used were one of an oil type, and dextrin, and both were very easily distributed. Taking that factor into account, the amounts of those two binders which should be used were definitely proportional to the size of the sand grain in the mass of sand used. He appreciated that cereal binders with low solubility were now being used considerably, and that their distribution, of course, was a factor of the mill and not necessarily a factor of the grain size of the sand. However, he did believe that the grain size of the cereal binder would be a contributing factor to the ultimate strength obtained.

Discussing the possibility, mentioned by Mr. Tipper, of applying the findings to the control of synthetic moulding sand practice, he said that he and his colleagues were doing that in their foundry in selecting sands, but also in another way in that all their synthetic sand was based on the core sand. The core sand disintegrated and the burnt core sand was used as the basis of the synthetic sand. In other words, they bought no sand at all for moulding purposes. That practice was working very well in the steel section of the plant, where the strength of the core was regulated so that it disintegrated in sufficient proportion to balance the wastage from the sand system.

As to the remark by Mr. Tipper that the grouping could be obtained on the basis of the British Standards Institution sieves, he said he had confined himself to the Institute of Mining and Metallurgy sieves, as he had found them most convenient. Nevertheless, he welcomed Mr. Tipper's remarks that the B.S.I. sieves could be applied.

Expressing appreciation of the remarks by Mr. Rees concerning the value of the Paper, he welcomed those remarks, particularly from a University with a reputation such as that of Sheffield, and from Mr. Rees himself, who had contributed considerably to all the pioneer work in this country on sands, whether moulding sands or core sands.

"Some Iron Castings for Steelworks Plant," by J. Roxburgh, was also presented during this technical session.

DISCUSSION

Composition and Section

MR. A. E. MCRAE SMITH commented first on the composition of the metal used, and said it had occurred to him that in most cases the aggregate of total carbon content plus silicon was rather higher than he would have expected in cast irons used for castings of heavy section, in some cases apparently 7 in. and over. He wondered whether the figures, especially those for silicon, were average figures, or were minima or maxima.

A factor which appealed to him was that in most of the cases quoted the sulphur content was remarkably low, and he asked whether that result was achieved by the selection of low-sulphur raw materials or by any de-sulphurising process.

Brinell Hardness of Alloyed Cast Irons

Referring to two alloy cast irons mentioned in Mr. Roxburgh's Paper, in the sections dealing with rolling-mill castings and rollers for hot reel coilers, he had noted that in the iron which had attained a Brinell hardness number of 275 to 300, part of the chromium was replaced by molybdenum; that hardness was attained in the non-heat-treated castings. In the second iron, however, which was heat-treated, there was no molybdenum, according to the figures given. He asked if that were really so.

Further, he was rather doubtful that, in sections such as those referred to, one would be able to achieve regularly the high hardness figure of 300 Brinell. He knew that, with 1-in. or 2-in. sections in the composition mentioned, one might expect to attain a Brinell hardness of 260 to 280, but he did not wish it to be assumed, particularly by those who bought castings, that one could always achieve a minimum Brinell hardness of 300 with that composition.

Running Methods

MR. A. J. SHORE, dealing with Mr. Roxburgh's description of the casting of rollers, 1½-in. thick, for hot reel coilers, asked whether, if the rollers had been, say, 4 in. thick, Mr. Roxburgh would still have used the two rather small top runners of ⅜-in. diameter, with 12 in. of tapered head? Would he, in making what amounted to a cylinder on end, lean towards the small pencil type of runner, or would he use a much larger diameter runner, in casting a thick section cylinder? Presumably, the job was a dry sand job.

Author's Reply

MR. ROXBURGH, replying to Mr. McRae Smith, said that the practice at his works was always to time the running of the bigger jobs, and in that respect they were able to build up data which they had found to be very useful indeed.

Dealing with the question concerning the analysis of the metal used in some of the bigger castings, where the total carbon plus silicon figures seemed to be high, he said that the figures given were average figures. When dealing however with very large quantities of metal, of anything from 20 to 40 tons, although in his opinion it was perfectly right in theory to aim at very low carbons and silicons, yet in practice it created a lot of difficulties in the actual casting operations. Therefore, he had selected very carefully the materials used in the mixtures, in order to get a close-grained material; in some cases the carbon was from 2.92 to 3.2 per cent. in the final castings, and with the silicon at 1.1 or 1.2 per cent., the structures obtained, and the castings when machined, came out very well indeed.

As to the fairly low sulphur content of the irons, he said that in that connection again the selection of the materials was important, and in some of the refined irons he had used he had specified low sulphur content—0.03 to 0.04 per cent.—in order to allow for the pick-up in the cupola melting.

With regard to the alloy cast iron rollers which had attained a Brinell hardness of from 275 to 300, he said that in the main they were within those limits; some were 280, some 290 and some had Brinell hardness figures up to 300. The metal for the smaller rollers had a nickel content of 1.75, whereas in the larger rollers the nickel content was 2.5 to 3.5, and that was why the molybdenum was omitted in the latter.

Dealing with Mr. Shore's question as to the type of runners he would have adopted if the rollers had been 4-in. thick instead of 1½-in. thick, he said he would still run the castings from the top. Quite a number of castings of that nature, 4-in. thick, were made at his works, and he would simply increase the number of top gates, having 4 or 3 instead of 2, and he would keep them as small as possible. In the casting of all the special irons he had found that the head was a very important factor. One might find that for ordinary irons 1-ft. of head was quite sufficient, whereas for some of the special irons a head of 18-in. or 2-ft. might be necessary. So that, for the castings under consideration, if they were 4-in. thick, he might manage with a head of 12-in., because the section was fairly uniform, or, on the other hand, he might increase the head.

On the motion of Mr. F. J. Cook (Past President), seconded by Mr. T. H. Turner, a hearty vote of thanks was accorded the authors of the Papers.

Book Review

The Microscope in Elementary Cast-Iron Metallurgy. By Roy M. Allen. Published by the American Foundrymen's Association, 222, West Adams Street, Chicago, Ill. Price 3 dollars.

This monograph is unusual, because it has been published on account of the demand for copies when given as a Paper to the American Foundrymen's Association in 1931. It is also interesting as an example of the application of one method of scientific study to one branch of manufacture, since there appears to be a demand for more elementary statements devoted to a particular purpose.

The metallurgical exposition follows normal lines, but occasionally one wonders if simplicity of statement has not been forgotten, for instance, in the following: "Whereas pearlite, because of the peculiarity of iron in assuming allotrophic forms at different temperatures (alpha and gamma irons), is not a mass eutectic, but an individual grain eutectic."

As might be expected, there are a few statements upon which there is no general agreement. In discussing the effects of elements on cast iron, the author describes nickel as being equal to half the silicon in greying power, whereas one-third is more usually accepted. Again, iron described as poor-wearing chill on account of containing graphite or mottle can hardly be regarded as chilled iron.

In describing the results of some experiments in heat-treatment, the author is very sound in hinting at what may be done in the future and in urging his readers to "plan for great developments." In Chapter V the equilibrium diagram is explained, and a proposed new diagram put forward in which ferrite is replaced by "silicoiron," that is, a diagram to cover silicon-iron-carbon alloys under "true equilibrium conditions." This may be quite useful, as the author suggests, in considering heat-treatment, until such time as the phase boundaries have been accurately explored. In the meantime Maurer's and other diagrams might have been usefully given, and more easily understood by the beginner.

The preparation and examination of micro-specimens are standard descriptions, apart from the liberal supply of grinding and polishing machines and somewhat elaborate microscopes, all of which are apparently supplied on a much more generous scale to the beginner in America than in Britain. Even so, some metallurgists still prefer rubbing specimens down by hand with a sheet of fine emery paper on a well-planed strip of wood, reserving a simple machine for final polishing.

From an instructional standpoint, the book is illustrated with numerous excellent micrographs, some at 2,000, 3,000 and even 4,500 magnifications, although only an obscure hint is given that the beginner should limit his aspirations to more moderate figures. The illustrations of manganese sulphide and martensite are particularly good. The book is written in a modest and reasonable style, and answers its purpose very well.

It should prove very useful to a keen foundryman desirous of attaining proficiency in micrography.

A. ALLISON.

Catalogue Received

Core Dressings. A leaflet received from Foundry Services, Limited, of Long Acre, Nechells, Birmingham, 7, describes and prices two new brands of core dressings bearing the trade names of Corecoat and Ferro-Corecoat.

Cutting Tools for Cast Iron*

By H. H. BEENY,† M.Met.

While research is necessary to interpret practical experience and extend fundamental knowledge, the machining of metals is not a subject which lends itself kindly to academic treatment, owing to the large number of variables involved. Fortunately the practical problem can be divorced from theory, as workshop methods, which are based upon a vast amount of experience, are very largely standardised and simplified. With machine tools of known capacity, the concern is mainly with cutting speeds and feeds which affect the floor to floor time for the work-piece, and with the length of time the tool material will continue to produce an accurately-machined part without re-grinding and re-setting. Habitually with automatic and semi-automatic machine tools, a cutting speed below the maximum is chosen in order to complete a batch of work without breaking down to adjust the tools, as this latter operation in a high-production multi-tool set-up can involve a considerable loss in output.

In the larger manufacturing organisations, metals being cut are carefully controlled in chemical and physical quality, permitting the establishment of cutting-speed charts for each grade for the guidance of the operator. The depth of cut is frequently not a matter of choice, but is often predetermined by the allowance found necessary on castings, bars and forgings in order to eliminate skin defects and dimensional variations. In the medium and light engineering trades, these allowances are kept as small as possible in order to save material, so that machining cuts nowadays tend to be lighter and at higher speeds than of yore. The selection of the most suitable tool material is a critical matter, and may determine the success or failure of a machine tool for a particular operation. It is the object of the present Paper to depict the general machining characteristics of cast iron and to show which of the available tool materials are most likely to yield the greatest speed and economy in production.

Machining Properties of Grey Iron

In some respects ordinary grey cast iron is an easy metal to machine, as the chips break away in front of the tool in small pieces without any great exertion of force. With any metal the form of chip generated is mainly governed by the ductility or, to include the time element, by the capability of the metal for undergoing very rapid plastic deformation without complete rupture. The graphite flakes which are scattered through grey cast iron, and the nature of the metal itself, which is heavily loaded with embrittling elements such as silicon and phosphorus, are sufficient to prevent ductility and to cause the formation of a disjointed powdery swarf, instead of the continuous ribbon-like chip which is characteristic of the tougher metals.

The type of chip formed when machining a metal is very important, as it affects the proportion and intensity of the destructive influences on a tool. These influences are heat, abrasion and stress, the last taking forms which are more or less static due to the resistance of the metal to tearing, shearing and bending, and also dynamic on account of vibration set up in the work or machine tool or due to intermittent cutting. A strong, tough ribbon-like chip from a tenacious steel delivers a high degree of stress upon the nose of the tool and, at the same time, owing to the rapid sliding action over the cutting face and the internal friction set up in tearing and deforming the chip, much heat is developed.

Tool Requirements

Under such circumstances mechanical strength is the main requirement for the tool, and modern cobalt high-speed steels with a Vickers pyramidal hardness of about 851 and a tensile strength of about 150 tons per sq. in. will put up a very good performance at cutting speeds ranging from 70 to 250 ft. per min., particularly as a coolant fluid is normally available to take away a considerable proportion of the heat. The severity of the conditions may, however, be gauged from the fact that cutting pressures on the nose of the tool range from about 100 tons per sq. in. when machining mild steels up to 200 or even 250 tons per sq. in. for the higher-tensile alloy steels. It is fortunate that, with grey cast iron, the pressure is only approximately 50 tons per sq. in., so that mechanical conditions are easier and the extremely hard and durable, but somewhat more brittle sintered-carbide tools are able to function with a greater margin of safety. As a matter of interest, however, it should be pointed out here that suitable compositions and grades of these tools are being very successfully used for medium and finishing cuts on steel at turning speeds ranging up to as much as 1,000 ft. per min.

Relative Machining Speeds

It has been shown that cast iron does not impose heavy destructive stresses upon the tools, but what is the position in regard to abrasion and heating? It is significant from this point of view that leaded-brasses, magnesium and most aluminium alloys can be turned at 1,000 to 2,000 ft. per min. with carbide tools, whereas grey cast iron of roughly similar tensile strength and no ductility has to be removed at much lower speeds, which vary from 120 ft. per min. for a strong, close-grained low-phosphorus metal up to 800 ft. per min. for a soft annealed well-fettled casting. With steels, the tensile strength is the main guide to the cutting speed, but carbon content is also recognised to exert a powerful influence upon the rate of tool wear; or, in other words, increasing the carbon percentage sharply increases the abrasiveness of the cut. In good-quality irons, the combined carbon is in the region of 0.70 or 0.80 per cent., so that the matrix is pearlitic and corresponds to the composition and structure found in a high-carbon steel.

The strong action of the combined carbon upon the machinability in the case of grey cast iron is illustrated by the fact that an annealing treatment which destroys the constituent, converting it to soft ferrite and graphite, makes a marked improvement in the speed and ease of handling in the machine-shop. With the same traversing feed, cutting speeds may be doubled while multiplying the life of the tool by from three to six times. This striking difference in quality is undoubtedly due very largely to a big drop in the abrasiveness of the metal, but it cannot be entirely overlooked that the annealing also usually reduces the tensile strength, and this also will have an ameliorating tendency. It is unfortunate from the machining point of view that the annealing of irons of commendable quality reduces the wear resistance in addition to the strength, so that it is an unsuitable process for many castings.

The important influence of combined carbon applies not only, of course, to ferritic and pearlitic grey cast irons, but extends to mottled and white castings, where the constituent appears in the massive as well as in the pearlitic form. Speeds are much reduced, as one would expect, but with a suitable grade of sintered-carbide tool, white cast iron possessing a Brinell hardness number around 415 can now be successfully turned, the cutting speed being about 25 ft. per min. Even alloy white cast irons containing nickel and chromium, in which the combined carbon which is normally pearlitic is retained as hard martensite, can be machined with these tools at from 10 to 15 ft. per min. as an extreme case, although the Brinell number of the metal may be as high as 555. This contrasts with a turning speed of from 200 to 500 ft. per min. for an average unannealed grey iron possessing a Brinell number of about 200 (5-mm. dia. steel ball, 750-kg. load).

Influence of Constituents on Machining

So far prominence has been given to the combined carbon content, as apart from the graphite, which gives to cast iron its unique character, this constituent is by far the most important ingredient. Manganese and sulphur have little or no direct influence. These elements, along with silicon, which is of course very potent in this respect, exert substantial control of machinability only in so far as they alter the form of the carbon in the iron. In considering these chemical factors, it must not be overlooked, however, that the machinability of cast iron is determined not only by its abrasiveness but also by its strength, because a strong iron presses the chip against the cutting face of the tool more heavily than does a weak iron and therefore intensifies both abrasion and heating. Alterations in combined carbon content up to 0.90 per cent. affect the tensile strength, as has already been noted in connection with annealing.

Phosphorus existing either in solution or as the phosphide eutectic appears to have little direct abrasive effect within the limits usually found in commercial irons but increasing the amount of the element, say from 0.20 per cent. up to 0.90 or 1.00 per cent., causes a considerable loss in tensile strength and the overall machining quality is definitely improved. In a large machine shop, when changing over to lower phosphorus and stronger irons, slower machining speeds on planing had to be adopted. It is the author's experience that the importance of phosphorus, from the point of view of the machining of grey cast iron, lies in its effect upon tensile strength, the element making the metal weaker and more friable.

It is easy for confusion to arise when considering the machining quality of cast iron, as one is dealing with a complex operation on a complex subject, but the conclusions emerge that, in a major sense, combined carbon and tensile strength are the two factors which radically control the speed of metal removal for a given tool life. This conception simplifies the problem, as the action of other variants, both chemical and physical, can be established by their effect upon these two factors. This interpretation is intended to include additions of such alloys as nickel, chromium and molybdenum, as well as physical changes produced by melting and casting conditions. There is possibly an exception in the case of austenitic cast irons, which form a class apart.

In considering machining quality it will be appreciated that abrasion and heating of the tool go hand in hand. Thus a casting inadvertently produced in too hard a grade of metal will not only wear the cutting edges intensively, but the chips will come away so hot that they oxidise on the surface to brown and purple tints, instead of remaining grey, as with an iron of normal machining quality.

Foundry Influences

The survey deals so far with the properties of the metal itself, but actual castings are frequently very abrasive, due to adhering sand and oxide on the surface and to "cold shot" in the form of very hard pellets of white cast iron just under the skin. Fins or "flashes" at core prints and joints in the mould may strike a chill back into the casting, and the use of densenors, unless carefully arranged, will produce locally-chilled corners or areas on the castings. It is clear that efficient fettling, whether by shot-blasting, tumbling or pickling, has an important

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* Paper read to the International Foundry Congress in London.
† Alfred Herbert, Limited, Coventry.

ever, which was heat-treated, there was no molyb- Papers.

trade names of Corecoat and Ferro-Corecoat.

bearing on machinability, but this process cannot remove all the abrasiveness from the skin, and the practice in the workshop is, therefore, to take a deep cut and so get well under the harmful layer. With ordinary high-speed steel tools, the blunting effect of the casting skin is very noticeable, but the carbide tools are much more resistant, so that when foundry considerations permit, machining allowances can be reduced. These tools are also invaluable for dealing with castings such as those mentioned above, which are chilled in places or are generally too hard, and which create great difficulties for the older types of tool.

Reasons for Dry Machining

Cast iron is peculiar from the machining point of view because of the dusty nature of the swarf, which renders the use of cutting fluids well nigh impossible. Straight oils quickly become loaded with the finer particles and soluble oil emulsions tend to cause corrosion with the swarf and form hard masses which collect on the machine and choke up the tanks and delivery pipes. Another point which affects many metals is that cutting speeds with carbide tools are frequently very high, so that the fluid is scattered violently by the centrifugal action of the work in the chuck. For finishing cuts where heating of the work interferes with the accuracy of the final dimensions, there would be an advantage in providing a cooling fluid, but machine tools built for general use make no suitable provision for the elimination of the swarf from the liquid. On this account and because in most cases there is a further finishing operation such as grinding, the turning, milling, drilling and planing of cast iron are almost invariably done dry.

The abrasiveness of strong unannealed cast irons is frequently noticed when tapping, screwing or forming; with dry cutting the fine edge tends to dull and a lard oil or a high grade of blended fatty oil is often found advantageous, the liquid being brushed on in small quantities. Taps are often made of special carbon steel and the dies or form tools of high-speed steel, as hard carbide inserts of intricate design are expensive, and in the case of threads would be liable to breakage.

It has been shown that grey cast iron is a metal which is comparatively low in tensile strength, which possesses no ductility and which consequently breaks with a short chip. Nevertheless, it is highly abrasive, due to skin conditions, and the combined carbon normally present. As castings, this metal is, moreover, subject to occasional sand inclusions and chilled spots and is machined dry, so that the tool is not aided by the cooling and lubricating action of a cutting fluid. A combination of heat and abrasion is the destructive influence which has to be countered, and as carbide tools have proved eminently successful for all types of cuts on cast iron, it may be of interest to look for those features which have contributed to this success.

Sintered Tools

The sintered hard carbides possess a tensile strength of about 70 tons per sq. in., which is fully equal to the figure for Stellite, but is only half that for hardened high-speed steels. The cold hardness, however, which ranges from 1,320 to 1,545 Vickers pyramidal numeral, is infinitely superior to that of either rival. Even more striking is the fact that at a dull red heat (600 deg. C.) the hardness is still much greater than that of the other materials *when determined in the cold state*. The author has made hardness tests at 600 deg. C. using a Rockwell machine with a diamond cone indenter under 60 kg. load and found by conversion that high-speed steels varied in Vickers hardness at this temperature from approximately 535 for a 14 per cent. tungsten steel up to 640 for an 11 per cent. cobalt high-speed steel, while Stellite gave a value of 620. Sintered tungsten carbide, however, maintained a hardness equivalent to 970 Vickers pyramidal numeral at 600 deg. C. It is abundantly clear that this retention of hardness, which at normal cutting heats on cast iron must be well over 1,100 Vickers pyramidal numeral, renders this tool material eminently suitable for the dry-machining of iron castings and accounts for the high cutting speeds which are maintained for long periods without regrinding. The hard carbides appear not to benefit from the application of a cutting fluid, and their use on cast iron is therefore peculiarly fitting.

Reactions on Machine-Tool Design

The comparative fragility of the sintered hard carbide tools and the tremendous speeds necessitated by their unique cutting powers created a considerable revolution in machine-tool design. To-day construction aims at greater rigidity in all parts coming under the reactive stresses of cutting, and at higher spindle speeds with ample driving power and diminished vibration. The machine beds of grey cast iron are skilfully braced against twisting and bending stresses, and the tools themselves are firmly held so as to minimise any yielding under the forces of cutting. Hardened and ground high-tensile alloy steels replace older and softer materials for headstock gears, so that the increased pitch-line velocities may be sustained for long periods with silent running. Roller and ball bearings replace white-metal and phosphor-bronze for many applications, and lubrication systems have been improved by providing automatic pump filtration of the oil along with sight feeds.

The driving power is most frequently a self-contained electric motor of from two to three times the horse-power found in older machines of the same dimensional capacity; this is necessary to provide the steady feed and absence of any tendency to stalling or hesitancy under cut, which is a frequent cause of breakage with carbide tools. The machines are expressly built to withstand the gruelling action of modern high-speed cutting and are necessary if the full advantages of rapid production and economy available with carbide tools are to be attained. It is important to note that these machines permit increased rates of metal removal even with high-speed steel tools or Stellite, due to their greater mechanical stability and power. With cast iron, which does not demand the highest speeds, the older machines are capable of improved service with carbide tools owing to the much longer life between grinds and the better sizing of the work-parts, which results from the slower deterioration of the cutting edge.

The large differences existing in the quality and capacity of machine tools, on account of age or make, render it difficult to give precise cutting speeds, but 200 to 250 ft. per min. may be taken as average machine-shop practice for turning grey cast iron with carbide tools; this compares with 140 ft. per min. for Stellite and 70 ft. per minute for 18 per cent. tungsten high-speed steel, all the cuts being taken dry. The introduction of carbide tools has permitted a reduction in piecework rates of 30 per cent. in many cases, while at the same time increasing the earning power of the operator. On machine tools embodying the latest construction and design, still higher speeds are attainable with greater savings; it is interesting to note that carbide tips are regularly tested by turning grey cast iron at 700 ft. per min. on a modern lathe of heavy construction and power, the feed being 37 cuts per in. and the depth of cut 0.150 in.

Nature of Newer Materials

It is well known that the new super-cutting materials consist of minute particles of intensely hard metal carbide, which are cemented together with cobalt by a final sintering process in the neighbourhood of 1,500 deg. C. Tungsten carbide, which is believed to have the best all-round properties, is the universal choice for machining cast iron, but on steel where the conditions are very exacting due to the strong continuous chip, which tends to "crater" the top face of the tool, tantalum, titanium and molybdenum carbides are also used. The hard carbide materials are, of course, unforgeable, so that the cutting tips have to be given their final shape during manufacture, an allowance only being made for grinding and burnishing or lapping operations, which are conducted after brazing on to a steel shank. The material itself is expensive, so that many designs of tip are made, in order to conform as closely as possible to the final desired shape.

Various grades of composition of the tips are also necessary, the hardest grade for fine boring or light cutting on hard cast iron or chilled iron rolls being low in cobalt and composed of especially fine tungsten-carbide particles; such tips give a Vickers pyramidal numeral of fully 1545.

A grade for general work on cast iron retains the fineness in the constituent powder, but has extra cobalt to cement the grains more firmly together. This grade is more serviceable than the previous one under average machining conditions involving heavy cuts and feeds. The additional cobalt, which is evenly distributed between the hard carbide grains, reduces the indentation hardness slightly, so that the Vickers pyramidal numeral falls to about 1478. For planing or for intermittent cutting on grey cast iron, a softer and tougher grade is available, which has coarser particles of tungsten carbide and a larger proportion of cobalt. The average Vickers pyramidal numeral for this grade is 1372. It may be mentioned that with up-to-date machine tools, intermittent cutting on grey cast iron is now a routine operation.

There seems little need to detail the methods employed in tipped-tool manufacture, as these are already well known and as full information is readily supplied when required by the various firms marketing the hard carbide products. Alfred Herbert, Limited, have found a silicon brass to be very successful as the brazing medium for fastening the tip on to the seating milled into the carbon steel shank. The procedure, which is simple to carry out, has been standardised for a number of years and brazing troubles are practically unknown. It is important that the shank itself should be of ample dimensions, in order to support effectively the somewhat brittle tip and to damp down cutting vibrations. Special silicon-carbide and diamond wheels have been developed, so that the fine, smooth cutting edge, which is so essential for the maximum cutting efficiency of the tip, can be quickly produced. If care be not taken a rough crumbled edge is formed which quickly fails in use.

A typical lathe tool for work on grey cast iron will have a top rake angle of 8 deg., a clearance angle of 6 deg., and will be capable of sustaining feeds as coarse as 25 cuts per in. With the hardest grade of carbide tip, a stronger tool angle is obtained by using 0 deg. top rake along with a clearance angle of 4 deg. Such a tool will machine white cast iron at between 10 and 30 ft. per min., with a feed of 100 to 250 cuts per in. and a depth of cut up to $\frac{3}{8}$ in.

Advantages Shown

The advantages of sintered tungsten-carbide tools for cast iron may be summarised as follow:

(1) Cutting speeds are from three to five times greater than with the best high-speed steels.

(2) The abrasive action of sand and scale is much better resisted than with high-speed steel, and, when foundry considerations permit, the machining allowances on castings can be reduced.

(3) At moderate cutting speeds which do not overheat the work, the sizing of parts is greatly improved owing to the wear resistance of the tools, and in some cases grinding can be eliminated.

(*Concluded on page* 574.)

† Alfred Herbert, Limited, Coventry.

Progress of Inverse Segregation During Solidification*

By Dr. JOSEPH ALEXANDER VERO†

[Presented on behalf of the Magyar Ontodei Szakem berek Egyesulte]

Introduction

In the extensive literature dealing with inverse segregation, experiments are described which were carried out mainly to prove or disprove different theories of segregation, while important particulars which undoubtedly were germane to the understanding of this interesting phenomenon have been entirely neglected. To fill up one of the existing gaps, the present investigation was carried out; and in order to visualise the formation of inverse segregation during solidification, the following particulars were taken into account:—(1) How the extent of inverse segregation changes with the progress of solidification, in the solid part of the ingot; and (2) whether and how the average composition of the solid part and that of the liquid are changed during solidification.

Previous Work

The literature of the subject recently has been reviewed in separate Papers, [1] [2] and by reference to these it will suffice to mention only those experiments which are akin to these described in the present research.

THE PRESENT RESEARCH

Experimental

The experimental alloy, composed of 95 per cent. of commercial aluminium and of 5 per cent. of "Banca" tin was prepared in a gas fired furnace. This alloy solidifies, according to the equilibrium diagram of the Al-Sn alloys,[6] over a very wide temperature range, the primary and the secondary constituent differ much from each other, and in addition its analysis is very simple; thus it is very suitable for segregation experiments.

Definite portions of this alloy were remelted, well stirred and then samples were taken by means of a small plumbago spoon. The mould, 100 mm. high, had a diameter of 65 mm. at the top and of 45 mm. at the bottom and a wall thickness of 20 mm.; at the bottom it was open. Before pouring, the mould was preheated to 125 ± 5 deg. C. The alloy was cast at the temperature of 750 ± 10 deg. C. On pouring, the mould stood on a level bed of slightly preheated moulding sand, and immediately by the side of the mould a cavity was made in the sand. After a part of the alloy had solidified in the mould, the latter was tilted and the liquid residue ran into the cavity of sand.

The pit samples gave the original composition of the alloy. By making two radial cuts through the shell, samples were obtained giving information on the average composition of the solidified parts of the ingots; the remainder of the shells was then machined, layer by layer—the layers were 2 mm. deep—to detect the segregation. The residual liquid which solidified in the conical cavity of sand was sampled by taking two radial cuts reaching the centre.

Analysis was effected by dissolving the sample in HCl and titrating with $FeCl_3$; proper choice of methods and standardised careful work resulted in an accuracy of ± 0.01 per cent.

Experimental Results

The results of analytical examination together with the data characterising the stages of solidification were collected in the upper part of the Table I. The progress of solidification is indicated in the second column of this table by the relation of the cross-sections of the whole ingot and of the shell, calculated as a ratio of the corresponding weights. Since the compositions of the single melts vary to some extent, the divergences of the tin contents of the single layers from the original composition of the corresponding melt are shown in the lower part of the Table I, enabling comparisons to be made between the different castings.

Casting I indicates the earliest stage of solidification. It was 2 to 3 mm. thick; thinner shells could not be produced, as they broke down and fell from the mould during inversion. At this stage of solidification there is a slight, but distinct, segregation of the inverse type; the average compositions both of the bled ingot and of the residual liquid agree accurately with the composition of the melt. The latter observations also proved valid for the later castings, except in the case of Sample III, which will be discussed later. Thus the liquid part of chill cast ingots is not affected by any segregation taking place in the solidified parts of ingots and consequently the segregation is only connected with those parts where solidification has already begun.

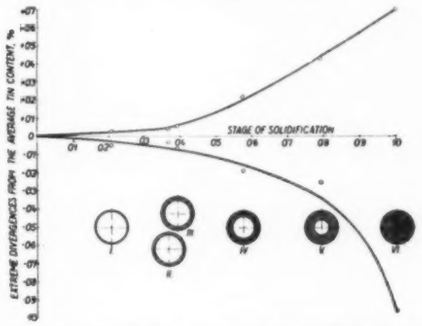

FIG. 1.—PROGRESS OF INVERSE SEGREGATION AS PRESENTED BY THE EXTREME VALUES OF COMPOSITION.

With the progress of solidification, the segregation steadily increases in extent, as is indicated especially in the data in the lower part of Table I; this increase is first quite slow (*vide* castings II and III), but as soon as the half cross-section of the ingot has solidified, it becomes more rapid and the major part of the total segregation arises during the solidification of the internal parts of the ingot.

This progress of segregation is clearly shown by Fig. 1, wherein the extent of segregation, expressed by the divergence of the extreme tin contents from that of the cast alloy, is plotted against the cross-section relationships indicating the stage of solidification. The positive values, referring to the periphery of the castings, increase in a uniform manner, while the curve of the negative divergences shows a steep deflection

TABLE I.—*Analytical Results.*

No. of the casting.	Stage of solidification.	Tin content, per cent., of the layer, proceeding from the periphery: Pit sample.	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	Whole casting.	Residual liquid.
I	0.208	5.27 5.26	5.28 5.30	5.21 5.20	—	—	—	—	—	—	—	—	—	—	—	5.265 5.26	5.26 5.27
II	0.365	5.16 5.18	5.19 5.23	5.18 5.18	5.15 5.13	—	—	—	—	—	—	—	—	—	—	5.16 5.18	5.18
III	0.390	5.24 5.26	5.11	5.06	4.99	—	—	—	—	—	—	—	—	—	—	5.05 5.06	5.27 5.29
IV	0.575	5.07	5.30 5.28	5.05 5.06	5.00 5.00	4.875 4.88	—	—	—	—	—	—	—	—	—	5.05 5.06	5.07 5.07
V	0.790	5.26 5.28	5.70 5.70	5.58 5.59	5.40		5.17		5.02		—		—		—	5.25 5.31	5.27 5.82
VI	1.00	5.21 5.21	5.91 5.90	5.80	5.55		5.05		4.90		4.55		4.40		4.25	—	—
I	0.208	—	+0.025	−0.05	—	—	—	—	—	—	—	—	—	—	—	0	0
II	0.365	—	+0.04	+0.01	−0.03	—	—	—	—	—	—	—	—	—	—	0	+0.01
III	0.390	—	+0.055	+0.005	−0.065	—	—	—	—	—	—	—	—	—	—	—	+0.03
IV	0.575	—	+0.22	−0.015	−0.07	−0.19	—	—	—	—	—	—	—	—	—	−0.015	0
V	0.790	—	+0.43	+0.315	+0.13		−0.10		−0.25		—		—		—	+0.01	+0.005
VI	1.00	—	+0.70	+0.59	+0.34		−0.16		−0.31		−0.66		−0.81		−0.96	—	—

In the discussion on Genders' Paper[3] supporting the gas pressure theory, Archbutt mentions that a bled ingot made from an aluminium-copper alloy (11.57 per cent. Cu) contained at the periphery 12.27 per cent. of copper, thus indicating the presence of inverse segregation at an early stage of solidification.

Bled ingots were produced and examined by W. Gödecke,[4] [5] again with the intention of showing that the first formed solid shell of the ingots consists of primary crystals rich in the high-melting point constituent of the cast alloy. The shells differed, however, from the cast alloy in their composition by a few hundredths of 1 per cent. only, while 1 per cent. or more was expected from consideration of the equilibrium diagram. Herefrom it is concluded that the residual liquid may not be separated from the solid shell, and that it is incorrect to assume normal segregation due to the formation of the primary crystals and proceeding to the final inverse segregation.

* Paper read to the International Foundry Congress in London.
† University Lecturer, Royal Hungarian Palatine-Joseph University, Metallurgical Institute, Sopron, Hungary.

beginning at about the cross-section ratio of 0.6. The alteration of the negative values is due, at least partly, to the different thickness of the innermost layers.

Both curves of Fig. 1 have a distinct tendency to run into the 0 point of the co-ordinates representing the original composition of the cast alloys, though the nearest experimental points at about 0.2 cross-section ratio lie a little distant from the 0 point. Here the course of the curves is not perfectly determined; the curves as drawn doubtlessly fit into the experimental points. If so, then the composition of the first formed layer of chill cast ingots must be identical with that of the cast alloy.

The experimental alloy solidifies over a very wide temperature range, and thus, on bleeding, the shell remaining in the mould is obviously not perfectly solid, but pasty; one might think that further cooling may produce changes in the distribution of tin and that therefore the examination of the shells does not give a true picture of the actual state. To clarify this doubtful point, one of the castings, No. III, was quenched in ice water, together with the mould, immediately after bleeding. On quenching, the inner surface of the shell was immediately cooled by the water, while the periphery facing the mould was obviously kept hot by the heavy mass of iron. Thus quenching reversed the direction of heat flow in the shell; nevertheless, it was unable to give rise to any difference in the distribution of tin in comparison with the similar casting No. II, but the average tin content was considerably lower than that of the cast alloy. On quenching, the shell was covered by many cracks and the water which entered them caused appreciable corrosion, due to the great potential difference between tin and aluminium; in consequence of the oxidation of aluminium, lower tin contents were obtained.

Correlation of the Results with Segregation Theories

The fact that the segregation is slight in the early stages of solidification and that its major effect takes place during the second part of solidification, proves in the first instance the correctness of that theory that the segregation is a consequence of the migration of the residual liquid from the centre towards the outside of the ingot at some stage prior to complete solidification. The migrating liquid will become richer in the lower melting point constituent with falling temperature. At an early stage of solidification, the solid shell is thin and the temperature differential between its internal and external parts may be only small; thus migrating liquid will also be enriched in the fusible constituent to a small extent and the migration of a liquid—which does not differ much from the original composition of the alloy—may produce slight changes in the local composition of the casting. With the progress of solidification, however, the temperature differential existing in the solidified part and the enrichment of the fusible constituent during its migration increase, giving rise to a more extensive segregation.

With regard to the cause of the migration of the residual liquid, there are divergent opinions. It is not the author's intention to draw conclusions from the results in this respect, but an observation noted in many cases, and which is not discussed in the literature, is worth detailing. Immediately before the end of solidification, a visible contraction of the residual liquid occurs at the bottom of the shrinkage cavity, and in consequence porosity appears between the primary crystals, being visible at low magnifications. This observation is explainable only by suction action exerted by the previously solidified parts of the ingot, but not by the evolution of gases; gas evolved close to the surface of the casting would preferably disappear in the air, rather than drive the residual liquid through some obviously existing resistance towards the outside of the casting.

The conclusion that the composition of the first formed solid layer of chill cast ingots is identical with the composition of the cast alloy, as shown by Fig. 1, is in contradiction to the fundamental assumption generally used in explaining the phenomena of segregation. According to its final form,[1] this assumption says:—"From consideration of the equilibrium diagram of a binary alloy system, it is possible to visualise one type of segregation. The first crystals to separate from the molten alloy are rich in higher melting point constituent and occupy a position close to the mould face. As solidification proceeds, the crystals grow towards the centre of the ingot, pushing before them the residual liquid, which is becoming continually enriched in the lower melting-point constituent. The latter might be expected to be found, therefore, in greatest quantity in the central, last solidifying part of the ingot. The segregation in this case is described as 'normal,' . . ." This interpretation of the process of solidification may be found in every Paper or text book dealing with segregation; its original author is uncertain. It is, however, possible to pursue its existence as far as to 1906, when C. R. Andrews gave a similar description of the process of solidification in the discussion of Talbot's[7] report on the segregation in steel ingots.

The concept in question rests upon two facts: (1) That, according to the equilibrium diagram, crystals rich in the high melting-point constituent separate first from the melt; and (2) that on pouring into metallic moulds, the solidification begins at the mould face and proceeds then, layer by layer, towards the centre of the ingot. A combination of these facts, postulating that the first formed solid layer of the ingot consists essentially of the first formed crystals, led to the opinion outlined. The two facts, however, are quite independent of each other, and their combination is, generally speaking, inadmissible; on the contrary, neither does the equilibrium diagram indicate that the first separated crystals form a perfectly solid layer, nor may it be assumed that the shell growing inwards consists solely of primary crystals.

Because the distribution of the constituents of an alloy is probably uniform in the filled mould before the crystallisation begins, a solid layer being rich in the high melting point constituent could be produced only by some motion—such as the migration of the constituents. This migration, however, is not to be deduced from considerations of the equilibrium diagram, but only if at least one of the following possibilities proved correct:—(1) if prior to crystallisation, a corresponding composition-gradient were present (inverse Ludwig-Soret effect); (2) if the primary crystals formed in the melt could change their original position inversely, as advanced by Watson,[8] or (3) if the residual liquid would be squeezed out from the region of primary crystallisation, by some considerable increase in volume. The first two possibilities need not be considered[9 10] and also the third one does not occur in every case of segregation. Thus there is no reason to assume, even from considerations of the equilibrium diagram, the early formation of a solid shell, rich in the high-melting-point constituent, since experimental results disprove this opinion.

But independently from the circumstance whether the above possibilities may be active or not on solidification, they doubtless are processes of which there is no indication in the equilibrium diagram. The equilibrium diagram gives information only on the succession of the processes and reactions of crystallisation, but not on the distribution of the alloying elements in a casting, and neither the one nor the other type of segregation may be derived from this diagram. The compositions of castings cooled under several conditions were doubtless uniform, if only the processes indicated in the equilibrium diagram did take place on solidification and if secondary factors did not play a part. On explaining the phenomena of segregation the equilibrium diagram may be used only so far as to show that at some stage of solidification there is a residual liquid differing in composition from the cast alloy and being thus able to produce local changes of the composition of the casting, if it is forced to migrate by secondary factors.

A further consequence of these considerations is that the differentiation of "normal" and "inverse" segregation may not be postulated with reference to the equilibrium diagram. It is, however, not suggested to reject these familiar premises, but only otherwise to explain their origin, the one type, for example, as "normal," *i.e.*, frequent in steel ingots.

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Air-Conditioning in Blast Furnace Operation

An experiment is being carried out by the Woodward Iron Company of Alabama, in which a blast furnace is supplied with preconditioned air. The object of the experiment, according to "The Iron Age," is to control the amount of moisture in the air in an effort to obtain greater uniformity in pig-iron.

The installation includes refrigeration and air-conditioning equipment to control the amount of moisture in the blast. The air is cooled to a constant predetermined dewpoint, then heated to a temperature of 1,000 deg. Fah. with no water added. A daily average of 20 tons of water are removed from the air. The conditioned air is then supplied to the blast furnace at a pressure of from 5 to 30 lbs. per sq. in.

Cutting Tools for Cast Iron

(*Concluded from page* 572.)

(4) Harder and stronger grey cast irons can be efficiently and economically dealt with in the machine shop, so that the foundry can with confidence put in the best quality of product, knowing that patches inadvertently chilled will be machined. There is less temptation to anneal grey iron castings.

(5) White iron castings are dealt with which were previously unmachinable or could only be cut with great difficulty.

(6) Due to the higher cutting speeds and greater life of the tools, piecework rates can often be reduced by 30 per cent. or more, while permitting larger earnings by the operator.

Acknowledgments

In conclusion, the author would like to express his appreciation and thanks to the directors of Alfred Herbert, Limited, machine-tool makers, of Coventry, for permission to publish the Paper, and to the British Thomson-Houston Company, Limited, of Rugby, for information relative to the manufacture of "Ardoloy" hard carbide tips.

Core-Shop Control

By J. J. SHEEHAN, B.Sc., A.R.C.Sc.I.

(*Continued from page 554.*)

Washes

Core washes are used extensively in the cast iron, steel and non-ferrous foundries. The function of the wash is to protect the surface of the core from the action of the molten metal, *i.e.*, from erosion, penetration between sand grains or penetration of cracked cores. These penetration effects are increased by higher pouring temperatures.

Silica flour is used in the steel section, and has recently replaced plumbago and blackings in the iron foundry. Talc is used in the non-ferrous section. The silica flour mixture used consists of:—Silica flour, 21 galls. (210 lbs.); Colbond, 9 galls. (72 lbs.); water, 36 galls.; dextrin solution (50 per cent.), 4 pints.

This gives a Beaumé gravity of about 52 to 60 deg., and is thinned down to requirements, *e.g.*, Beaumé 50 deg. for port and runner cores and 48 deg. for jacket cores (these cores are

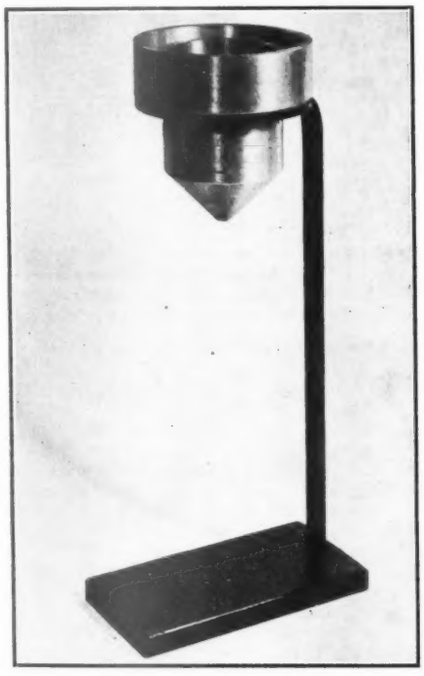

FIG. 30.—VISCOMETER.

dipped), and 40 deg. for cores that are sprayed, such as end cores, body cores and chest cores.

The change to silica flour was necessitated mainly by a change in the type of iron used, but a considerable economy also resulted. The iron now used in the foundry is a copper-chrome alloy with a low phosphorus and total-carbon content. Its main characteristics are: phosphorus, less than 0.10 per cent.; total carbon, 3.10 to 3.30 per cent., and silicon, 2.10 to 2.30 per cent.

The pouring temperature of such an iron needs to be high. This high temperature requires mould and core conditions approximating to those obtaining in steel practice. It was found that graphite did not give sufficient protection to the cores when high pouring temperatures were used. The better performance of silica wash in this respect depends upon the consideration that, while the heat capacities of both types of wash are approximately equal, the thermal conductivity of the graphite wash is more than one hundred times as great as that of the silica wash. Using a graphite wash, the rate of heat transmission was sufficiently rapid to expand and crack the core before the metal had set, thus allowing the metal to penetrate the crack, forming a fin which was difficult to fettle off.

The equality in the heat capacities of the two washes is not evident from a consideration of the specific heats of graphite and silica only; the relative amounts of these materials per square inch of surface area of the core must also be taken into consideration. These relative amounts were determined experimentally, using a paint viscometer of the type illustrated in Fig. 30.

The dry materials in the silica wash used were in the amounts already mentioned; the materials in the plumbago or graphite wash were identical, but for the substitution of graphite for silica flour.

The viscosities and Beaumé strengths of the water suspensions, and the thickness and weight of dried wash on clean glass plates were determined. The following table gives the results obtained:—

Series.	Type of wash.	Temp. of wash. Deg. C.	Viscosity.	Beaumé strength. Deg.	Thickness of coating. Ins.	Wt. of coating.* Grams.
I	Graphite ..	17.0	54	33	0.00275	0.95
	Silica ..	17.2	54	52	0.00425	1.56
II	Graphite ..	16.8	46	30	0.001	0.48
	Silica ..	16.0	46	50	0.0025	0.62

* The weight of coating is the weight of dried material on $10\frac{3}{16}$ sq. in. of glass plate.

The viscosity of 54 given in Series I is the viscosity of the wash which is used when cores are dipped. The viscosity of 46 given in Series II is the viscosity of the wash which is used when cores are sprayed.

The following calculations show that heat capacities of the washes for equal areas of core surface in Series I are equal, and in Series II approximately so.

Series I.—

Specific heat of graphite = 0.4670.
Specific heat of silica flour = 0.29.
Wt. of graphite on $10\frac{3}{16}$ sq. in. = 0.95 gms.
Wt. of silica on $10\frac{3}{16}$ sq. in. = 1.56 gms.
Heat capacity of graphite wash is 0.4670 × 0.95 = 0.44 calories.
Heat capacity of silica wash is 0.286 × 1.56 = 0.44 calories.

For Series II the relationship is:—

Heat capacity of graphite wash = 0.22 calories.
Heat capacity of silica wash = 0.18 calories.

The coefficient of thermal conductivity of graphite is 0.24 and of silica 0.0025, so that in Series I the rate of conduction of heat through the wash is proportional to $0.24 \times \frac{1}{0.00275}$ for graphite and $0.0024 \times \frac{1}{0.00425}$ for silica, *i.e.*, the rate of conduction is $\frac{0.24}{0.00275} \times \frac{0.00425}{0.0024}$ or 154.5 times greater through the graphite wash.

The authorities for values used in the above calculations are:—

Specific heats.	Authority.
Graphite at 978 deg. C. is 0.4670	Geber.
Silica at 1,000 deg. C. is 0.286.	Calculated according to Woestyn's hypothesis.

Coefficient of thermal conductivity is defined as the quantity of heat which passes through a cubic centimetre in one second divided by the difference of temperature in deg. C. between the two faces through which the heat passes.

Graphite (consolidated), 0.24 .. .. Wologdine.
Silica granulated (consolidated), 0.002 to 0.003 Wologdine.

The relationship found in the above experiments between the weights of graphite and silica flour in suspension in a wash at equal viscosities is confirmed by the work of Bingham and Durham* (from which the graph shown in Fig. 31 is taken), and by E. Lips and H. Nipper in "An Investigation of the Influence of Crystallisation on the Fluidity of Melts,"† from which the graphs in Figs. 32 and 33 are taken.

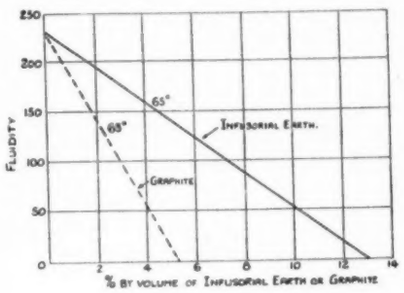

FIG. 31.—FLUIDITY $\left(\frac{1}{\text{VISCOSITY}}\right)$ OF SUSPENSIONS OF INFUSORIAL EARTH AND GRAPHITE IN WATER AT DIFFERENT TEMPERATURES. (BINGHAM AND DURHAM.)

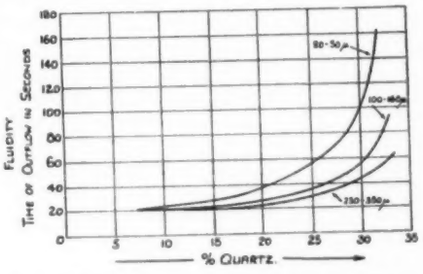

FIG. 32.—TIMES OF OUTFLOW OF VARIOUS MIXTURES OF QUARTZ IN SUSPENSION IN TERMS OF GRAIN SIZE AND CONCENTRATION. (LIPS AND NIPPER.)

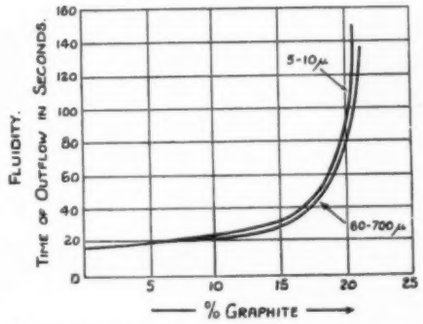

FIG. 33.—TIMES OF OUTFLOW OF VARIOUS MIXTURES OF GRAPHITE IN SUSPENSION IN TERMS OF GRAIN SIZE AND CONCENTRATION. (LIPS AND NIPPER.)

A secondary result of this investigation was a more accurate control of the washes used in the core shop, based on the viscosity of the washes rather than the Beaumé gravity. The wash is now made up in large capacity tanks in the core shop to a specified Beaumé gravity, and minor adjustments made if necessary from a determination of the viscosity carried out in the

(*Concluded on page 578.*)

* Trans. Amer. Chem. Soc. Vol. XLVI, 1911, p. 278.
† "Die Giesserei," July, 1938, p. 369.

Effect of Melting Conditions on Gas Unsoundness in Metals*

By G. L. BAILEY,† M.Sc.

Unsoundness in cast metal, *i.e.*, the presence of cavities, large or small, may be due to several causes, including contraction of the metal during solidification, mechanical entrapping of extraneous gases and gases evolved on solidification. The present Paper is concerned only with the last of these with particular reference to the influence of melting conditions on gas absorption. That serious unsoundness can be caused by the liberation of gases from the molten metal during cooling and solidification is a well-known fact of which illustration is unnecessary. The

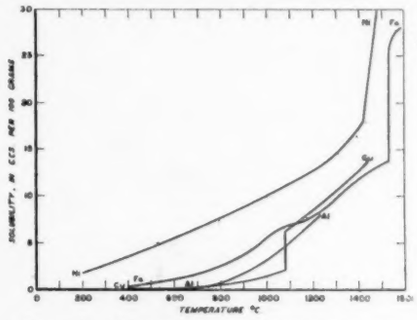

FIG. 1.—SOLUBILITY OF HYDROGEN IN NICKEL, IRON, ALUMINIUM AND COPPER.

gas-holes formed by the trapping of the evolved gas in the casting may be spherical cavities of fair size or fine interdendritic films, depending to a great extent on the freezing range of the alloy. The influence of such defects on appearance, mechanical properties and tightness under hydraulic pressure is obvious, and in the melting and casting of most of the common alloys precautions are necessary to minimise unsoundness of this type.

In considering the possibility of controlling gas contamination during the melting operation it is important to know what gases are responsible for the trouble and to understand the mechanism of gas absorption and evolution in different materials. It is proposed, therefore, to refer briefly to the evidence available on gas solubility and the variations in solubility which result in gas unsoundness. Sources of gas contamination will then be discussed, and some suggestions for minimising gas absorption during melting will be explained. The principles of various methods of removing dissolved gases from contaminated metal prior to casting will be discussed briefly, but detailed consideration of such methods is outside the main subject.

Gas Solubility in Metals

The solubility of gases in metals has been studied by a variety of methods, the most important and fruitful of which has been the measurement of the amount of gas absorbed by a metal when heated in an enclosed system at a known temperature and pressure. The experimental technique needs great care and a number of possible disturbing factors must be controlled.

Much effort has been devoted to the extraction of gases from a sample of metal heated *in vacuo*, followed by analyses of the gases evolved. Widely varying results have been obtained by this method, which is open to serious objections on various grounds, and the most reliable data are those obtained by the first method, one of the pioneers in the use of which was Sieverts.[1] The most significant feature of the results is that in general the solubility of gases is greater in liquid than in solid metals, and there is therefore, with rising temperature, a sudden increase in solubility at the melting point. Solubility in the liquid metal also increases as the temperature is raised still further, until a temperature is reached at which the vapour pressure of the metal itself becomes significant. Sieverts showed that the solubility of an elementary gas in a molten metal at a given temperature was proportional to the square root of the partial pressure of the gas in the atmosphere in contact with the metal, a result to be expected, since it is known that gas molecules dissociate on solution.

Hydrogen is the common gas most readily soluble in a large number of metals, and has consequently been the gas with which most of the experimental work on solubility has been done. Fig. 1 shows typical results for the solubility of hydrogen in iron, copper, nickel and aluminium. It will be seen from this that while in all cases there is an increase in solubility with increasing temperature in the liquid metal, solubilities vary considerably, particularly in the solid state in which, for instance, solubility of hydrogen in aluminium is too small to measure. The presence of hydrogen in these metals can be regarded as a true solution, the equilibrium conditions changing with temperature and pressure according to known laws.

Oxygen (or the metal oxide) is soluble to a considerable extent in some molten metals, such as iron, nickel and copper, but in others, *e.g.*, tin, zinc and aluminium, the oxygen solubility, if any, is very low and accurate data in these instances are lacking. Nitrogen appears to be insoluble except in those metals which are capable of forming nitrides.

These are the three elementary gases which are the most important in this connection, but solubility or otherwise of compound gases is equally important. Such gases as sulphur

TABLE I.—*Effect on Soundness of Bubbling (a) Nitrogen and (b) Hydrogen through Molten 93 : 7 Aluminium-Copper Alloy. Sand-cast Bars.*

Gas.	Treatment.		Total voids. Per cent.	
	Time.	Temp. Deg. C.	B.S.I. test-bar.	3 in. dia. cylinder.
Nitrogen	1 hr.	750 to 770	0.1	0.7
Hydrogen	1 hr.	740 to 770	2·3	3·1

TABLE II.—*Effect on Soundness of Bubbling (a) Nitrogen and (b) Hydrogen through Molten 5 per cent. Tin Bronze. 1½ in. dia. Bars.*

Gas.	Treatment.		Total voids. Per cent.	
	Time.	Temp. Deg. C.	Chill-cast.	Sand-cast.
Nitrogen	1 hr.	1,200	1.2	3.8
Hydrogen	½ hr.	1,190	2.5	9.7

dioxide and oxides of carbon cannot, according to Smithells,[2] be dissolved as such and can only diffuse into metals after dissociation. In general the two constituents of a soluble compound gas can co-exist up to a certain limit in equilibrium in the liquid metal. Interesting examples of this type of solution of compound gases are sulphur dioxide and water vapour in liquid copper. Both copper sulphide and copper oxide are soluble in molten copper, and in this case the "solubility" of sulphur dioxide increases with temperature very much like a simple solution.[3] The reaction between water vapour and molten copper has been worked out in great detail by Allen and his collaborators.[4] The water vapour is decomposed and the hydrogen and oxygen pass into solution in the melt in equilibrium. Allen and Hewitt[4] have worked out this equilibrium relationship (see Fig. 2) from which it is apparent that the solubility of hydrogen in copper is reduced by the presence of oxygen and *vice versa*. Increasing the temperature or the water vapour concentration increases the amount of both hydrogen and oxygen which can be retained but does not affect the general relationship.

It will be obvious that the constituent elements of a compound gas may be present in a molten metal or alloy in proportions widely different from those of the compound gas, and that their source may not have been the compound gas at all. An example of this is molten steel containing both carbon and oxygen, the source of the carbon being the pig-iron charged and that of the oxygen being an oxidising slag.

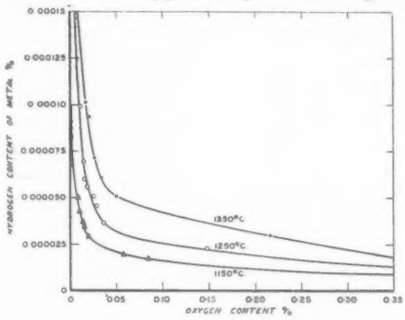

FIG. 2.—OXYGEN-HYDROGEN EQUILIBRIUM IN MOLTEN COPPER AT DIFFERENT TEMPERATURES.

The various gas-metal equilibria which are of importance in this connection cannot be dealt with exhaustively here, and these examples have been selected as illustrations of the reactions with which this discussion is concerned.

Formation of Unsoundness by Gas Evolution

The variations in solubility of an elementary gas with temperature (see Fig. 1) are reversible, and if a molten metal saturated with gas at a high temperature is allowed to cool, gas is evolved steadily as the liquidus temperature is approached, and there is a further evolution of gas during solidification. Gas evolved on solidification is inevitably largely trapped in the casting, but the gas evolved on cooling to the liquidus may or may not escape, depending on the conditions. There is, in fact, some doubt as to whether this gas does escape in practice. With slow cooling and exposure of a large surface area it does so, but under ordinary casting conditions it is possible that this gas is either trapped in the casting, owing to the rapidity of solidification, or held in the liquid metal in supersaturated solution and evolved on solidification.

Examples of simple hydrogen unsoundness are afforded by aluminium alloys and tin bronzes, to both of which nitrogen is inert from the point of view of the production of unsoundness. For instance, the results given in Tables I[5] and II[6] have been obtained during the course of researches by the British Non-Ferrous Metals Research Association on aluminium alloys and tin bronzes respectively. The unsoundness obtained after nitrogen-treatment can be assumed in each case to be due to shrinkage only, the increased unsoundness after hydrogen-treatment being due to evolution of hydrogen during solidification.

A point on which there is doubt is whether rapid cooling causes the retention of gas in the solid metal over and above the equilibrium condition. It is known, for instance, that a chill casting made from a gassy melt of bronze or aluminium alloy will contain far fewer gas voids than a sand casting. Reference to Table II shows this effect clearly, hydrogen-treatment having increased the voids by 1.3 per cent. in the chill-cast bar and by 5.9 per cent. in the sand casting. It is difficult to see how this can

* Paper read to the International Foundry Congress in London.
† Chief Officer, Development Department, British Non-Ferrous Metals Research Association.

Of interest to Pig Iron Users

THE STANTON METALLURGICAL SERVICE

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Where there are difficulties in works practice which can best be investigated on the spot, the service provides for a personal visit from a Stanton metallurgical expert, who will collaborate with the foundry staff.

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be explained other than by the retention of more gas in solid solution in the case of the chill casting.

The mechanism by which a single soluble gas causes unsoundness is thus fairly straightforward, but the part played by compound gases in causing unsoundness is more complex and difficult to evaluate. The simultaneous solubility of oxygen and hydrogen and oxygen and sulphur in copper have already been mentioned. In both cases the oxygen, having a very low solid solubility, is rejected from solution on solidification and reacts, forming water vapour and sulphur dioxide respectively. All known reactions of this type appear to involve oxygen as one of the reactants, and the solubility of oxygen in various metals is therefore a governing consideration. Where oxygen solubility is low, definite values for the solubility are rarely known, and it is often assumed that oxygen is insoluble in such alloys as tin bronzes in the molten state. It must be realised, however, that the amount of oxygen required to produce gross reaction unsoundness is very low. For instance, in a copper-base alloy, oxygen of the order of 0.0001 per cent. by weight would suffice to produce sufficient steam at the melting point to cause 5 per cent. by volume of cavities if enough hydrogen were available.

It was suggested by Daniels[7] that the solubility of oxygen in tin bronzes was sufficiently high to cause unsoundness by steam evolution resulting from reaction between hydrogen and oxygen in equilibrium in the melt. The evidence Daniels advanced was insufficient to justify this conclusion, but later work, still in progress, does suggest that this reaction can and does occur in tin bronzes.

Smithells[8] states that in the majority of cases gas unsoundness in non-ferrous metals is due to reaction between hydrogen in solution and oxygen, and that hydrogen alone diffuses so rapidly through most metals near their melting points that it can seldom develop as bubbles. While reaction unsoundness is extremely important, the author cannot agree that simple hydrogen unsoundness is so rare as Smithells suggests. For instance, in the case of aluminium it seems that oxygen solubility is sufficiently low to preclude reaction gas unsoundness and the author's colleague, Mr. W. A. Baker, has found that no more than minute traces of steam could be developed by treating molten oxide-bearing aluminium with hydrogen.

Reaction unsoundness is the basis of the production of rimming steels. Although the reactions occurring in this case are not fully understood in all points, there seems no doubt that in general McCance[9] is right in attributing the unsoundness to a reaction between carbon and oxygen co-existing in solution in the molten steel and evolving carbon monoxide on solidification. McCance suggests that the evolution of carbon monoxide is due to the rejection of oxygen from solution from the advancing face of the rim. This local concentration of one constituent disturbs the equilibrium and leads to the evolution of carbon monoxide. In practice the rimming action is controlled by maintaining a correct balance of carbon, oxygen and manganese. If the oxide content of the liquid steel is reduced below the solid solubility point, no rimming reaction can occur. The practice of deoxidising or killing steel with silicon or aluminium is effective because such additions remove the oxygen from the bath, and not because, as was at one time suggested, they serve the purpose of increasing the solid solubility of the gas in the steel. The same reaction occurs in nickel, carbon and oxygen being soluble in molten nickel and excess of oxygen above the solid solubility limit reacting with carbon (if enough is present) to evolve carbon monoxide on solidification. As in the case of steel, sound castings can generally be ensured in nickel and high-nickel alloys by suitable deoxidation.

Similarly, in the case of copper, the hydrogen-oxygen reaction, which is adjusted in tough pitch copper to form sufficient steam to neutralise the shrinkage of the metal and give a level set, can be suppressed by the use of deoxidisers, and the removal of most of the oxygen by means of phosphorus, zinc, etc., from tough pitch copper gives sound metal which solidifies with a deep pipe.

These considerations emphasise the importance of correct deoxidation of molten metals before casting in cases in which remaining oxygen can give rise to injurious reaction unsoundness. For deoxidation to be effective in any particular alloy, the oxygen must be removed to below the solid solubility limit, about which little reliable information exists.

There is, however, another aspect of reaction unsoundness which is extremely important when considering the effect of melting conditions. The reactants in solution in the liquid metal are in equilibrium, and an increase in the concentration of one reactant results in a decrease in the concentration of the other. Thus over-oxidation of a tough pitch copper will reduce the hydrogen content to such an extent that the copper will pipe to some degree on casting. Where there is any solubility of oxygen, therefore, melting under oxidising conditions and thus maintaining or increasing the oxygen concentration tends to lower the concentration of the reducing element (*i.e.*, hydrogen, carbon or sulphur) in the melt, until this ultimately reaches a value at which it does not cause unsoundness. Conversely, melting under reducing conditions may effectively ensure the absence of oxygen and thus eliminate the reaction, although perhaps introducing increased difficulties due to simple gas solution.

Sources of Gas Contamination

Raw Materials.—The inclusion in the charge of materials which contain gas, or which carry hygroscopic corrosion products, obviously constitutes a potential source of trouble. This applies particularly to aluminium alloys, and the work of Hanson and Slater[10] has clearly shown that prior exposure of aluminium or aluminium alloys to corrosive conditions leads to serious unsoundness in castings made from such metal. For instance, virgin aluminium ingots were exposed under different conditions and subsequently used for making up 3L11 sand castings.

Aluminium which had not been exposed and was not corroded gave, under the conditions of test, sound castings (density 2.79 g./cc.), but aluminium exposed outdoors for 6 months or in water for 2 months gave badly pinholed castings after remelting (densities 2.77 and 2.76 g./cc. respectively). This unsoundness is due to some extent to the corrosion product, aluminium hydroxide, holding moisture which reacts with the aluminium on heating, forming hydrogen, which is dissolved by the molten aluminium. It has also been suggested that during the course of corrosion at room temperatures atomic hydrogen diffuses into the metal, where it collects in any internal cavities that may be present.

(To be continued.)

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Core-Shop Control

(*Concluded from page* 575.)

laboratory. The instrument used is already shown in Fig. 30.

Defects in the wash can also be correlated to viscosity figures, and thus readily corrected. Some of the defects observed are illustrated in Fig. 34, wherein (*a*) shows a tear in the wash film (viscosity of silica wash 54 secs. and graphite wash 64 secs.); (*b*) shows granulations of the wash film (viscosity of silica wash 40 secs.), and (*c*) shows smooth finish (viscosity of silica wash 46 secs. and graphite wash 53 secs.).

Improvement in these illustrated conditions may also be obtained by modification of the amounts of materials used to make the wash, but once these amounts are decided upon, accurate reproduction of the good results obtained is dependent upon the maintenance of a correct viscosity value.

Laboratory control is also maintained with pastes, chaplets, parting powders, and core wires. In connection with these materials, however, no problem of sufficient interest to justify further prolongation of the Paper has arisen.

The preliminary work of this Paper was done in association with Mr. Parkes, of the British Cast Iron Research Association. Mr. Thonger, of the Austin Motor Company's laboratories, has been the mainstay of its continuation and completion. To both gentlemen and to the Austin Motor Company the author is much indebted.

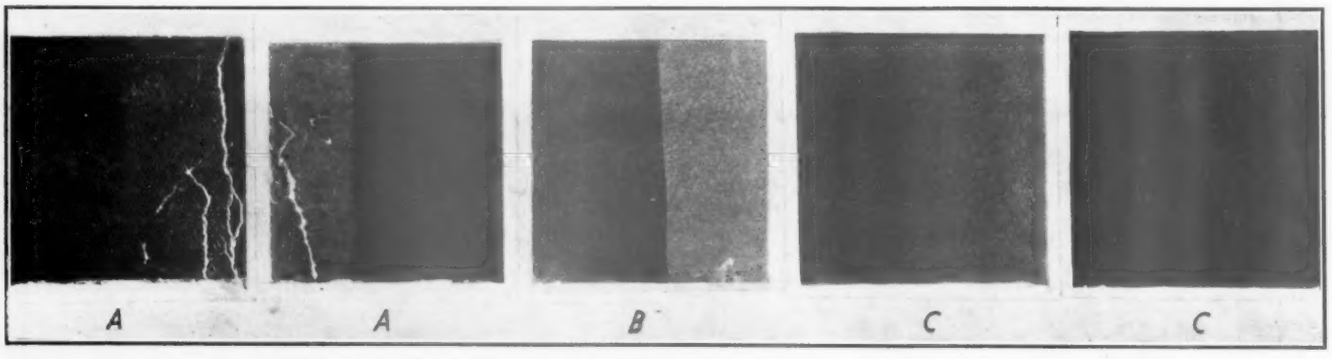

FIG. 34.—CORRELATION OF VISCOSITY FIGURES WITH CORE DEFECTS.

AT THE BORDER, BLAINE.

VANCOUVER.

BANFF STATION.

PHOTOGRAPHED BY T. H. GRAY.

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The Week's News in Brief

Trade Talk

RILEY STOKER COMPANY, LIMITED, have removed from 40/43, Chancery Lane, London, W.C.2, to 19, Woburn Place, London, W.C.1.

SIX THOUSAND CHILDREN of employees of Rolls-Royce, Limited, attended the annual field day and sports at the firm's Welfare Ground, Osmaston Park Road, Derby.

SWAN, HUNTER & WIGHAM RICHARDSON, LIMITED, Wallsend, have received an order for two high-class cargo vessels of 2,400 tons deadweight for the Ellerman Wilson Line of Hull.

THE ADMIRALTY have decided to entrust the construction of two escort vessels of the 1939 programme to the Furness Shipbuilding Company, Limited, Haverton Hill-on-Tees.

FRANCO TOSI S. A., Milan, which manufactures machinery and has a large steel foundry, made a profit of 7,100,000 lire in 1938, from which 6,354,954 lire has been paid as dividend on the 60,809,000 lire capital.

IT IS UNDERSTOOD that the aluminium works now in course of construction at Rheola, Neath, will be rather larger than was originally contemplated, and that the site already acquired will probably be extended.

INTERNATIONAL COMBUSTION, LIMITED, have removed their London office from Aldwych House, W.C.2, to 19, Woburn Place, W.C.1. The grinding, screening and filtering division of the company reports numerous orders from home and abroad for pulverisers, air separators, screens, pumps and other equipment.

AN ISSUE of 150,000 ordinary shares of 10s. each in James Howden & Company, Limited, is being made at 16s. 6d. a share. The company's products include land and marine boiler auxiliaries, air preheaters, forced- and induced-draft fans, marine furnace equipment, high-speed steam engines and turbines, dust-collecting plant, flue-gas-washing plant and other engineering work.

JOHN RHODES & SON, of Castleford, Yorks, have completed 60 years in business as crucible ironfounders. When, early in 1879, the late Mr. John Rhodes commenced business on his own account, he made a special study of glass-bottle mould production, and this is still the firm's specialty. The management of the business has just been placed in the control of Mr. Geoffrey H. Rhodes.

FELIX KÜHN, LIMITED, of Paragon Works, 33, Everton Brow, Liverpool, 3, have now changed the name of the company to Kresta Foundry & Engineering Company, Limited. The products of the company (which has been conducted for 47 years under the name of Felix Kühn) were formerly confined to cabinet hardware, but have been greatly increased in variety in latter years.

IT IS claimed that a record has been set up by five brothers named Hammond who have all been in the service of Joseph Sankey & Sons, Limited, Albert Street Foundry, Bilston. Last week Mr. William Hammond was made a presentation of a fireside chair and a wallet of notes when he retired from the firm after 41 years' service. Four of his brothers worked for the firm. These are their years of service :—Fred Hammond, 47 years; John, 46; Tom, 46, and Edward 37. The last three are now dead. The five of them total to 217 years' service.

MORE THAN £300,000 is to be spent on the modernisation of the plants of the Scottish Iron & Steel Company, Limited, at Coatbridge, as part of the programme of co-ordination for the merger with Wm. Baird & Company. This was revealed by Mr. Robert Angus, chairman of the latter company, at a special meeting in Glasgow on Monday, when conditions for the amalgamation were approved. The new company will be known as Bairds & Scottish Steel, Limited, and will have a combined capital of more than £2,000,000 controlling blast furnaces, coke ovens and collieries. Coke ovens will be erected at Gartsherrie, blast furnaces at Coatbridge and operated in conjunction with the plants of the Steel Company. Coke ovens will probably cost a further £250,000.

ONE OF the oldest and most historic buildings in Johannesburg changed hands a few months ago, when the Phœnix Foundry, Limited, acquired the site on which the former Kimberley Booysens Hotel still stands. The ground adjoins the property of the foundry at Ophirton, and is required for an extension of the premises which will probably be carried out next year. The Phœnix Foundry has a history which goes back almost to the beginning of Johannesburg, for it was established in 1895. The original foundry is now being used as a storeroom, and the premises which were completed two and a half years ago are among the most modern and well equipped in the Union. The present establishment was designed and constructed by the company themselves, and all side windows and roof windows were made on the premises. The shop is very light and spacious. It is covered by two Morris travelling electric cranes, of 7½ and 5 tons respectively, as well as an electrically converted hand crane capable of lifting 15 tons. There are three cupolas and the foundry specialises in mining requirements, sheave wheels and bearings, pumps, screens, tube-mill liners, and tube-mill feed hoppers. At present 60 Europeans and 120 natives are employed. The original foundry occupied 20 ft. by 60 ft., and has expanded gradually to its present area of 80 ft. by 200 ft. The coming extension will provide an extra frontage of 100 ft., and the premises will then measure 80 ft. by 300 ft. When this is carried out the foundry will probably be the biggest in South Africa under one roof. The works at present occupy 1½ acres of ground.

Personal

MR. GEORGE FERGUSON, assistant manager of Fred. Braby & Company, Limited, Springburn, Glasgow, has been appointed manager of the firm.

MR. H. H. MORGAN, manager of the Rail and Track Fastenings Department, Robert W. Hunt Company, Chicago, Ill., has been nominated President of the American Society for Testing Materials.

VISCOUNT RIDLEY has been appointed Vice-Lieutenant of Northumberland, in succession to Colonel the Hon. Harold Burge Robson. Viscount Ridley is a director of the Consett Iron Company, Limited.

MR. M. A. JANE, A.M.I.Mech.E., has been appointed by the British Thermostat Company, Limited, to take charge of their new Birmingham office at Essex House, 27, Temple Street, Birmingham, 2.

MR. JAMES HOWIE, London manager of Glenfield & Kennedy, Limited, Kilmarnock, is retiring at the end of June, after 52 years' service with the company. His successor is Mr. John Mair, who for the past 16 years has acted as the chief engineer of Glenfield & Kennedy, Limited, in India.

Wills

CRAMP, WILLIAM, D.Sc., of Edgbaston, Professor of Engineering at Birmingham University	£12,611
UPJOHN, T. E., of Weston-super-Mare, formerly sales manager at Birmingham of Stewarts and Lloyds, Limited ...	£20,613

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

Slough Abrasives, Limited, 107, Trading Estate, Slough.—Capital, £100. Manufacturers of and dealers in metallic abrasives, etc.

Aldam (Misterton), Limited, Station Street, Misterton, Doncaster.—Capital, £3,000. Ironfounders and engineers. Directors: W. T. Wales and Mrs. I. Wales.

J. Grayson Lowood & Company, Limited, Genefax House, Sheffield.—Capital, £100. Mine owners, dealers in refractories, etc. Directors: L. J. Rowley and T. Watson.

Harold Gummer & Company, Limited, 129, Carlisle Street East, Sheffield.—Capital, £5,000. Machinery and metal merchants, etc. Directors: H. Gummer and G. S. Sharman.

Menomat, Limited.—Capital, £6,000. Metallisation and electrical depoeition of metals on non-conducting materials, etc. Subscribers: F. H. Harman, 39, Cantley Gardens, Ilford, and L. C. J. Paterson.

Company Reports

Follsain Metals, Limited.—Total net loss for 1938, £4,258; debit forward, £24,251.

Greenwood & Batley, Limited.—Profit, £105,466; final dividend of 12 per cent., making 15 per cent. for the year to March 31.

Baker Perkins, Limited.—Net profit for the year to December 27 last, after £31,000 tax provision, £110,560; final dividend of 3½ per cent. on the ordinary shares, making 7 per cent.; to pension reserve, £5,000; to general reserve, £25,000.

Edgar Allen & Company, Limited.—Profit for the year ended March 31, after providing £46,000 for taxation, £80,315; brought in, £34,269; dividend on the cumulative preference shares, £10,875; dividend on the ordinary shares of 12½ per cent., £26,036; to general reserve, £35,000; to staff pension fund, £5,000; carried forward, £37,673.

Electric Furnace Company, Limited.—Net profit for the year ended March 31 last, £8,358; brought in, £8,972; interim dividend of 3½ per cent. on the cumulative preferred ordinary shares, £2,992; interim dividend of 2½ per cent. on the ordinary shares, £1,956; final dividend of 3½ per cent. on the cumulative preferred, £2,992; final dividend of 4½ per cent. on the ordinary shares, £3,521; carried forward, £3,130.

General Electric Company, Limited.—Profit for the year ending March 31, £1,776,099; brought in, £799,934; depreciation, £380,492; pension fund, £62,057; dividend on the "A" preference stock, £84,825; dividend on the "B" preference stock, £97,875; to taxation reserve, £430,000; to reserve account, £100,000; dividend of 10 per cent. and a bonus of 10 per cent. on the ordinary stock, £608,764; carried forward, £807,220.

Allied Ironfounders, Limited.—Full report shows: Dividends declared by the subsidiary companies for the year to March 31, after deduction of income tax, £192,109; investment income, etc., £8,857; brought in, £157,221; directors' commission, £4,961; dividend on 7 per cent. cumulative preference shares, £50,475; interim dividend on the ordinary shares of 4 per cent., £48,558; to obsolescence and depreciation, £20,000; to contingencies reserve, £15,000; final dividend on the ordinary shares of 5 per cent., £60,698; carried forward, £160,918.

Lead in Aluminium Alloys

A letter from a reader contains an interesting reference to lead in aluminium alloys. Apparently the two elements in the liquid state are not mutually soluble, but lead in the emulsified state can be absorbed to the extent of 5 per cent. In this condition, and when finely distributed, the lead has the property of adhering to any clay particles suspended in the melt, and the aggregates segregate and clean the bath. Moreover, lead is stated to attack, destroy and remove the oxide film on the surface of the bath, which, under neutral conditions, is cleaned.

The opinion (widely held) that lead additions to aluminium melts are deleterious is stated by the correspondent to be without foundation, as some alloys with high lead contents are appreciated for their excellent bearing and machining properties. Recent research results by Claus have shown that up to 1 per cent. is truly beneficial, whilst Röntgen and Winterhager in "Metallwirtschaft," Vol. 40, p. 1051, comment favourably upon the effect of $PbCl_2$ on the density, running properties of aluminium melts so treated, and on the oxide skin which is spherodised when suitable concentration is used. An addition of 0.075 per cent. $PbCl_2$ has been shown to produce optimum tensile strength and elongation. The decomposition of the $PbCl_2$ has a dual action, as the nascent Pb is a deoxidant and the gas liberation acts as a purifier.

New Laboratories for Battelle

New laboratories giving an additional space of 15,000 sq. ft. on five floors are in hand for the Battelle Memorial Institute, of which Mr. Clyde E. Williams is director. The new laboratories are required to cope with the expanding volume of industrial research.

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Raw Material Markets

Activity in most sections of the iron market continues to be disappointing, and current orders do not involve very substantial tonnages. No doubt the international situation must be held responsible to some extent for the lack of interest shown by consumers in forward contracts, but, nevertheless, it must be admitted that many iron users are not working at all satisfactorily. With the coming into operation on July 1 of lower quotations for hematite, there should be an immediate improvement in that section, as consumers are mostly well employed. The demand for steel continues to be extremely heavy, with producers hard pressed to meet inquiries.

Pig-Iron

MIDDLESBROUGH.—Only small orders are being placed for Cleveland foundry iron, and makers' stocks are quite ample fully to meet all orders at the present time. Scottish consumers of iron who formerly took quite large supplies from the Cleveland area are now able to satisfy their requirements in the Midlands at lower quotations, while the demand from overseas is negligible. It is fully expected that the existing prices for foundry iron here will remain in operation over the third quarter of the year.

With but a few days remaining before lower prices for hematite come into operation, activity in this section of the market is restricted, but a resumption of large-scale deliveries is looked for when supplies are available at lower quotations, many consumers being well employed. In fact, many users are now at about the end of their stocks and will be in urgent need of additional deliveries. Producers, on the other hand, are in possession of quite large stocks, and will appreciate the opportunity to reduce these to manageable proportions. For delivery on the North-East Coast as from Saturday next, East Coast hematite mixed numbers will be quoted at 115s. per ton, with Sheffield deliveries at 120s. 6d. and Midland deliveries at 126s., all less 5s. per ton rebate. Business with foreign countries would be done at prices rather below these figures, but there is little demand from overseas, as foreign consumers are able to obtain supplies elsewhere at quotations even lower.

LANCASHIRE.—Consumption of foundry pig-iron is moderately good in this area, but new business is small, and increasing use is being made of scrap material. The light-castings trade has experienced a very disappointing season; in fact, trade in this section has been little better than at the normally dull period of the year, and little improvement can now be looked for. Jobbing foundries, too, have not enjoyed a very active period in most cases. The most satisfactory sections continue to be the machine-tool and heavy engineering concerns. The demand for hematite is expected to increase substantially after the end of the month, when lower prices will rule.

MIDLANDS.—There has been no pronounced expansion in the demand for high-phosphorus iron during the week, and most consumers continue to have sufficient in stock to meet their requirements. The light-castings founders, especially, are badly placed for work, and the end of their normally busy season is now in sight. For the most part they have been on short time throughout. Prices of foundry iron are expected to remain unchanged for some time to come. Hematite users are in many cases busy on Government orders, either directly or indirectly, and consumption is likely to continue to be heavy for a considerable time. New business in this section has recently been on the quiet side, as reduced quotations will rule as from Saturday next, July 1. Many users have practically used up their stock, so that it is anticipated that producers will receive substantial orders in the near future. Low-phosphorus iron, which is also being used in large quantities by firms engaged in rearmament work, continues to move away satisfactorily. Some makers have sold as far ahead as they care, and may now be considered as being out of the market for further business at the present time. Prices remain uncontrolled.

SCOTLAND.—Although prices were recently reduced by 5s. per ton, the demand for foundry iron here continues to be rather quiet. Employment among the various light-castings foundries has recently shown a slight improvement, but the increased activity is still insufficient to make any noticeable difference in the demand for iron, most consumers being well covered for supplies. In fact, two foundries in the Falkirk district will be closing down at the end of the month, and the work on their books will be carried out by other plants in the combine. The full outputs of the local steelworks continue to move into consumption without any difficulty, but lack of raw material is hampering production to some extent. It is hoped that an increased production of basic iron will shortly be available.

Coke

Buyers of foundry coke have not shown much interest in forward booking of late, despite the fact that it has been announced that the existing quotation of 50s. 6d. for best Durham and Welsh coke will operate until the end of the year. No doubt there will be an early improvement in this position, as many consumers will need additional supplies in view of the fact that they are covered only until the end of the present month.

Steel

Heavy buying continues to characterise all sections of the steel market, and makers are fully engaged in complying with their commitments. The Lord Privy Seal recently announced that arrangements had been made with the steel industry in order to facilitate a further and considerable speed-up in the production of air-raid shelters. Orders for an additional 1,000,000 shelters are to be placed immediately, making a total of 2,500,000 delivered or on order. Business in all departments of the trade continues to be placed quite freely, but the past few days have, if anything, been a little quieter as far as new contracts are concerned. Output at some of the producing works is still adversely affected by the difficulties appertaining to the supply of raw material, but it is hoped that these will be lessened in the near future.

Scrap

The arrival of further supplies of scrap from the United States has relieved the stringency of supplies to some extent, but more is urgently required in order to meet the sustained pressure from the steelworks. Other grades of scrap appear to be rather more plentiful, and it is noticeable that certain of the larger consumers have reduced their orders of late. Nevertheless, scrap merchants are still having to ration deliveries in many cases.

Metals

The increasing tension in the Far East has reacted in the non-ferrous metal markets, and consumers are loth to enter into forward contracts. The tone on the London Metal Exchange, however, has been fairly satisfactory, and some consumers have displayed more interest in prompt business. A feature this week has been the advancement of the price of cash tin, which reached £230 per ton at one time, which is the upper limit of the £200 to £230 price range which the inauguration of the buffer stock scheme last year was designed to preserve.

Copper.—Consumers of this metal seem unable to take a really optimistic view of the future, owing to the general disappointment at the continued lack of stability in the international sphere, and business continues to be done rather spasmodically. Apart from the call for supplies from buyers connected with the rearmament programme, there is not much being done at the present time. A fair demand has been received from the Continent, while there have been welcome indications that United States consumers are getting near to the end of their stocks.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £42 1s. 3d. to £42 2s. 6d.; Friday, £41 16s. 3d. to £41 17s. 6d.; Monday, £42 to £42 1s. 3d.; Tuesday, £42 to £42 1s. 3d.; Wednesday, £42 to £42 1s. 3d.

Three Months.—Thursday, £42 6s. 3d. to £42 7s. 6d.; Friday, £42 2s. 6d. to £42 3s. 9d.; Monday, £42 6s. 3d. to £42 7s. 6d.; Tuesday, £42 6s. 3d. to £42 7s. 6d.; Wednesday, £42 7s. 6d. to £42 8s. 9d.

Tin.—Since attaining the price of £230 per ton the cash quotation for this metal has receded slightly. It is understood that the buffer pool authorities have made sales of metal for the first time. In fact, the turnover on the London Metal Exchange on Friday last exceeded 500 tons, but the turnover on Monday was only 145 tons.

The June issue of the "Statistical Bulletin" of the International Tin Research and Development Council, Statistical Office, 21, Prinsessegracht, The Hague (price 1s.), states that world tin production in April amounted to 11,200 tons, against 14,500 tons in April, 1938, bringing the total for the first four months of this year up to 44,700 tons, as compared with 57,800 tons last year. World apparent consumption in April is estimated at 14,300 tons (12,100 tons in 1938), and the total for the first four months at 50,100 (53,100) tons. This is equivalent to a monthly average of 12,525 tons, being but slightly below the average consumption during 1938. World tinplate production in April was 324,000 (256,000) tons, and in the first four months 1,175,000 (1,022,000) tons, an increase of 15 per cent. as compared with the corresponding period of last year.

Official quotations were as follow :—

Cash.—Thursday, £229 to £229 5s.; Friday, £229 15s. to £230; Monday, £229 10s. to £230; Tuesday, £229 15s. to £230; Wednesday, £229 15s. to £230.

Three Months.—Thursday, £224 15s. to £225; Friday, £224 15s. to £225; Monday, £224 10s. to £224 15s.; Tuesday, £224 to £224 2s. 6d.; Wednesday, £224 5s. to £224 7s. 6d.

Spelter.—The increase in the production of air-raid shelters, announced recently by Sir John Anderson, will no doubt mean an expansion of activity among the galvanisers, who are already working very well. In fact, this section is quite the most active of any zinc working-up industry. The Metallgesellschaft reports that the world's smelter output of zinc in March was 140,355 metric tons, making a total of 406,881 tons for the first quarter of the year, against 413,188 tons in the corresponding period of last year.

Daily market prices :—

Ordinary.—Thursday, £13 15s.; Friday, £14; Monday, £14 3s. 9d.; Tuesday, £14; Wednesday, £13 17s. 6d.

Lead.—While consumption is reported to be satisfactorily maintained in this country, consumers continue to purchase on a day-to-day basis rather than commit themselves ahead. In many respects this is just as well, as supplies at present are none too plentiful. Both Russia and Germany remain quiet consumers of the metal.

Day-to-day quotations :—

Soft Foreign (Prompt).—Thursday, £14 12s. 6d.; Friday, £14 11s. 3d.; Monday, £14 12s. 6d.; Tuesday, £14 11s. 3d.; Wednesday, £14 10s.

Scrap.—Rather dull conditions have prevailed during the past few days, and both home and export orders have been disappointing. It is hoped that there will shortly be an improvement, but the immediate future is not particularly promising.

Approximate selling prices for old metal are unchanged, at :—New aluminium cuttings, £71; rolled, £62; cast, £31 to £35; foil, £80. Copper, £38 to £43; braziery, £36. Brass (clean), £22 to £25. Zinc, £9. Lead, £13. Gunmetal, £38.

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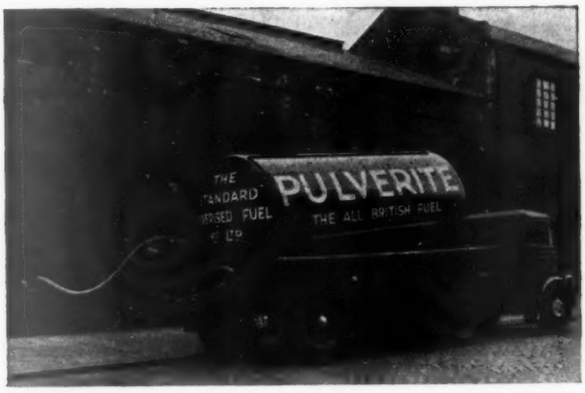

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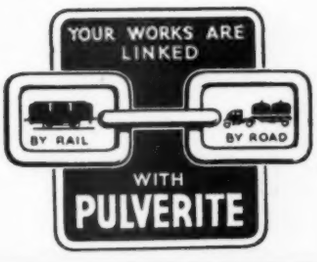

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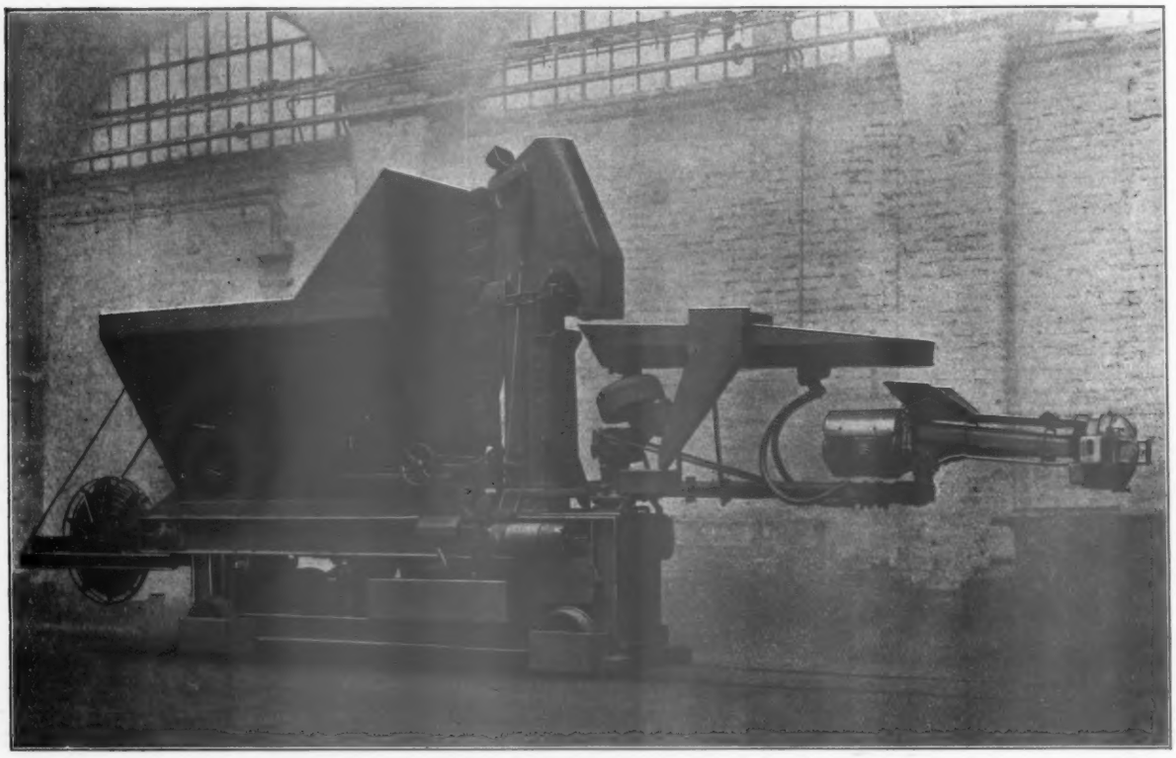

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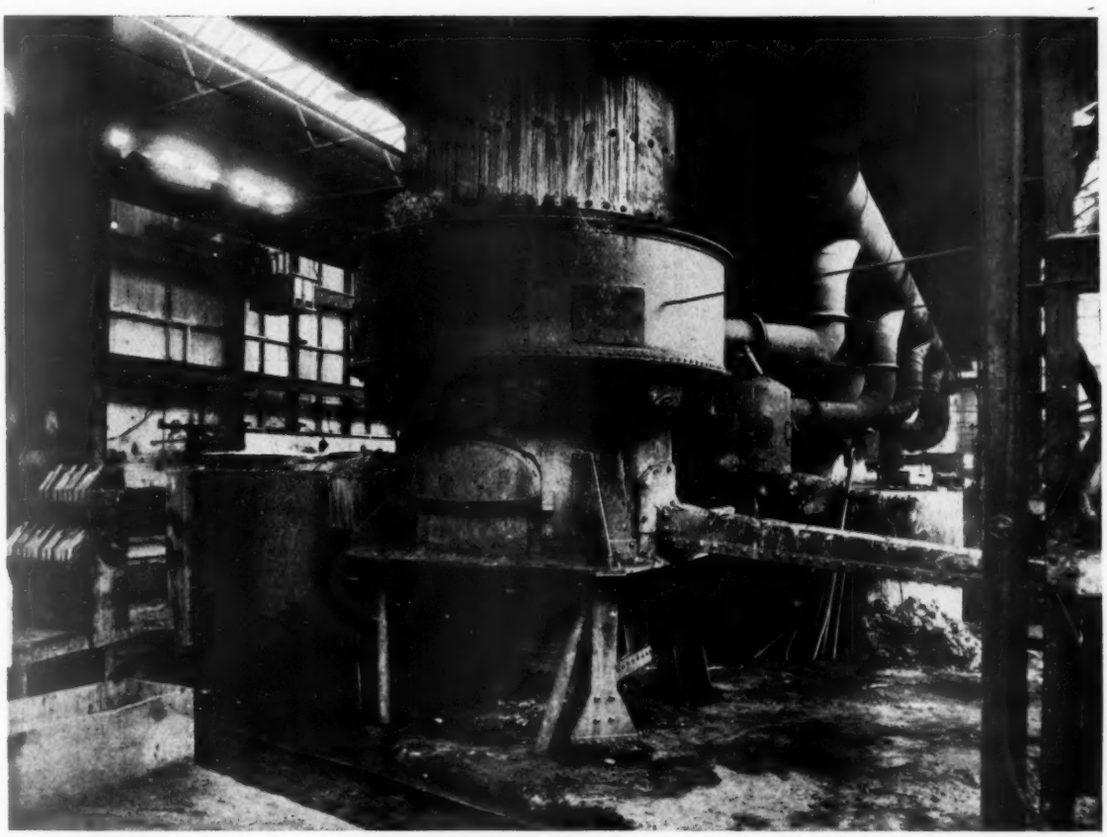

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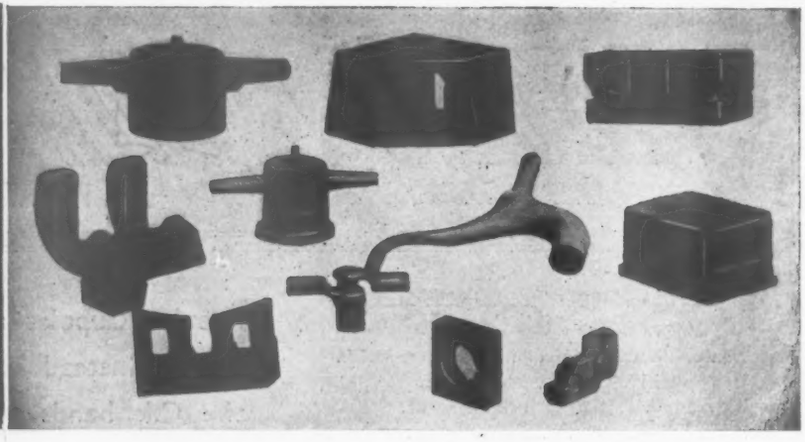

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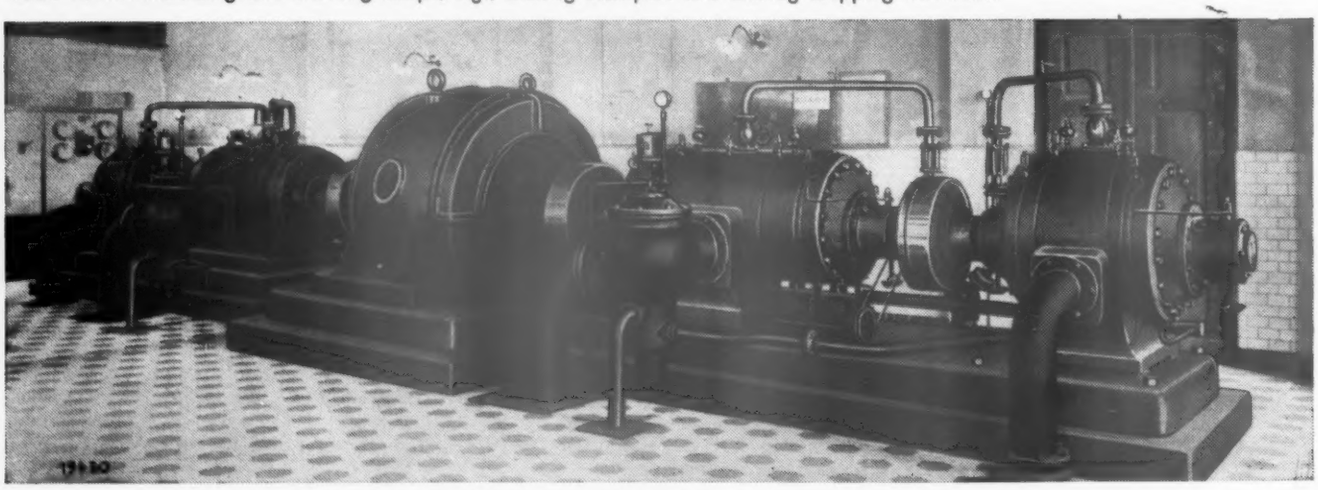

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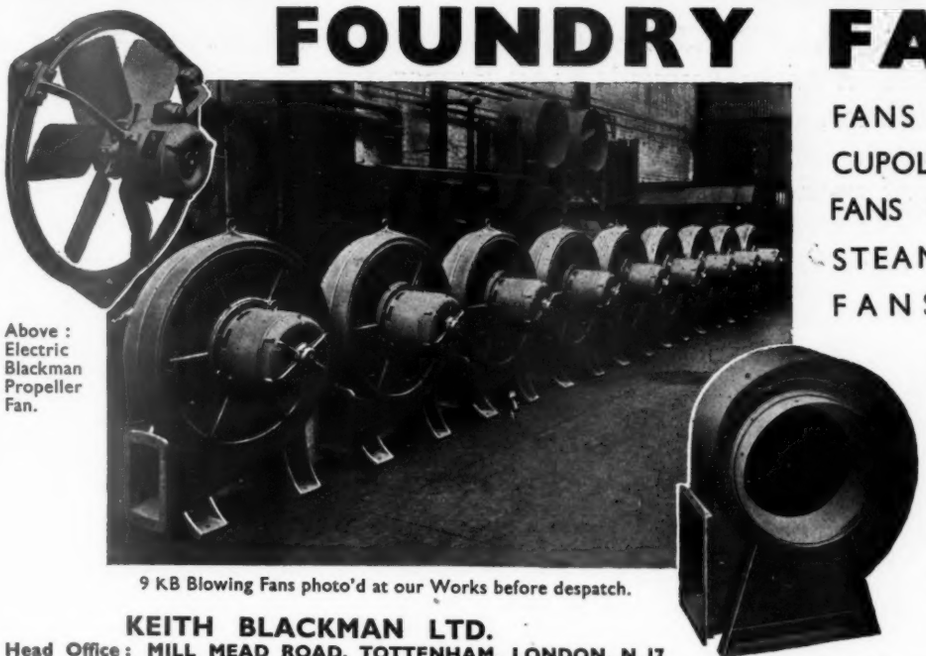

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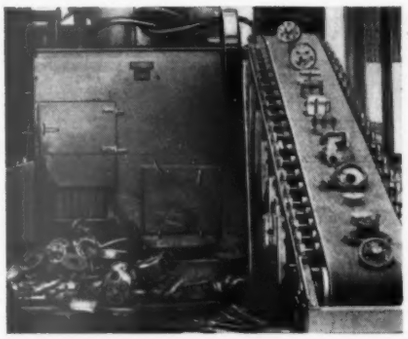

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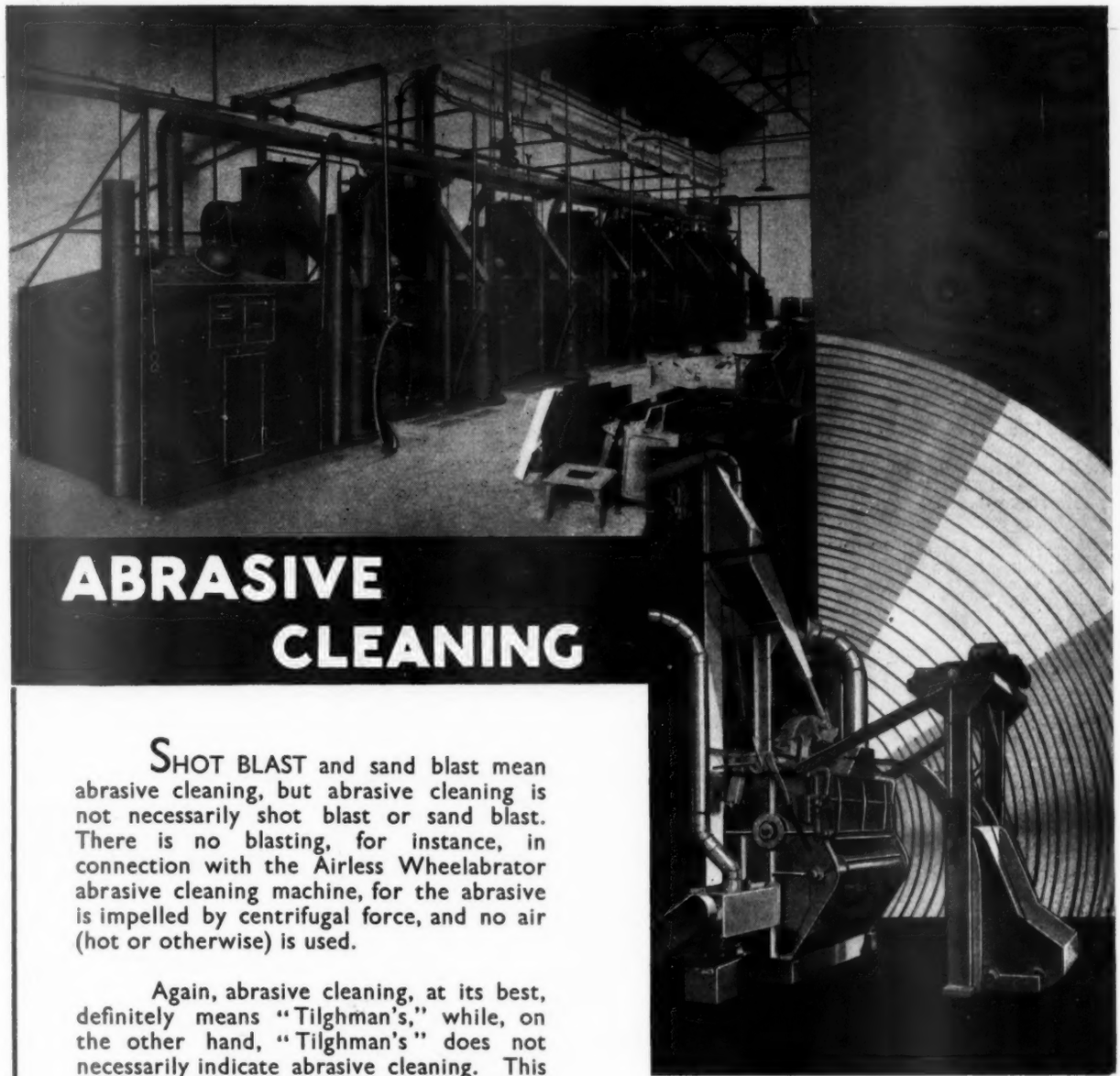

ABRASIVE CLEANING

SHOT BLAST and sand blast mean abrasive cleaning, but abrasive cleaning is not necessarily shot blast or sand blast. There is no blasting, for instance, in connection with the Airless Wheelabrator abrasive cleaning machine, for the abrasive is impelled by centrifugal force, and no air (hot or otherwise) is used.

Again, abrasive cleaning, at its best, definitely means "Tilghman's," while, on the other hand, "Tilghman's" does not necessarily indicate abrasive cleaning. This name also stands for the more efficient types of Dust Arresters and Air Compressors.

If "Tilghman's," however, is merely a name to you, you would do well to make their acquaintance. They are not only willing to send you all their catalogues, but also to clean some of your castings, entirely without obligation or cost, in either a shot blast machine or a Wheelabrator (bring your stop-watch !) to show you that their claims are not extravagant. Send a p.c. and arrange a demonstration, just to see for yourself.

968m

TILGHMAN'S

PATENT SAND BLAST CO., LTD.

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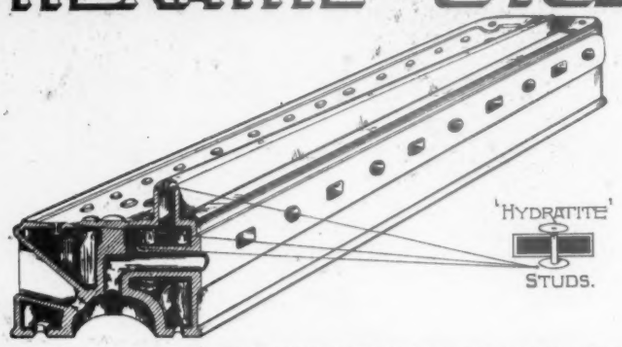

PRECISION 'HYDRA-TITE' STUDS FOR ALL CYLINDER CASTINGS

Also Makers of—

HINGE TUBE CHAPLETS, DOVETAILS, DOOR CATCHES FOR STOVE WORK, PERFORATED CHAPLETS, RADIATOR AND CYLINDER CHAPLETS, TOP HAT CHAPLETS, CORE WIRES, SKIMMING GATES, ETC.

PRECISION PRESSWORK CO. LTD.,

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Hydra-tite Studs have truly parallel stalks without fins, and are made from specially analysed material, keeping the sulphur and phosphorus as low as possible, coated with a non-ferrous metal to prevent corrosion under Foundry storage conditions.

All Hydra-tite Studs are to their stipulated sizes to within close limits and are the result of the accumulated chaplet experience of Foundry specialists.

They are used as standard in all high-class Foundries in the production of intricate cored work and may be used freely without any misgivings as to the closeness of "knit."

Hydra-tites are particularly suitable for Cylinder Heads, Housings, etc., and all high duty Diesel work. It is the rule for castings cored with Hydra-tite Studs to stand the usual 50 lbs. sq. in. "first time up" without "weeping" adjacent to the stalks and chemical injections, and rests are usually unnecessary to obtain Hydraulic Pressure tightness.

All sizes stocked from $\frac{1}{16}$" to 1".

SEND US YOUR ENQUIRIES WE CAN QUOTE YOU RIGHT

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EAGLE CORE OILS, CREAMS & SEMI SOLIDS

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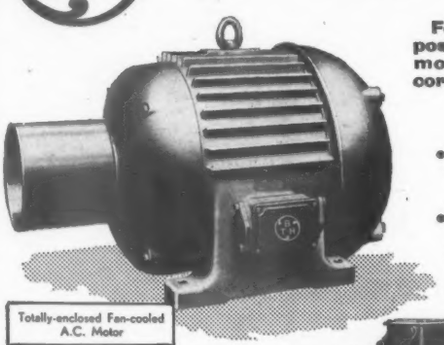

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For use in exposed positions or in dusty, moisture-laden, and corrosive atmospheres.

- Windings and internal parts are completely enclosed.
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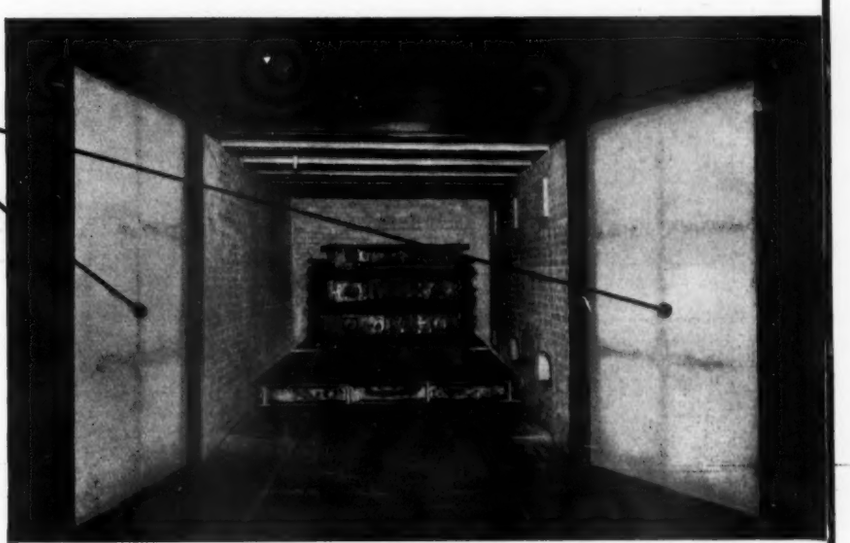

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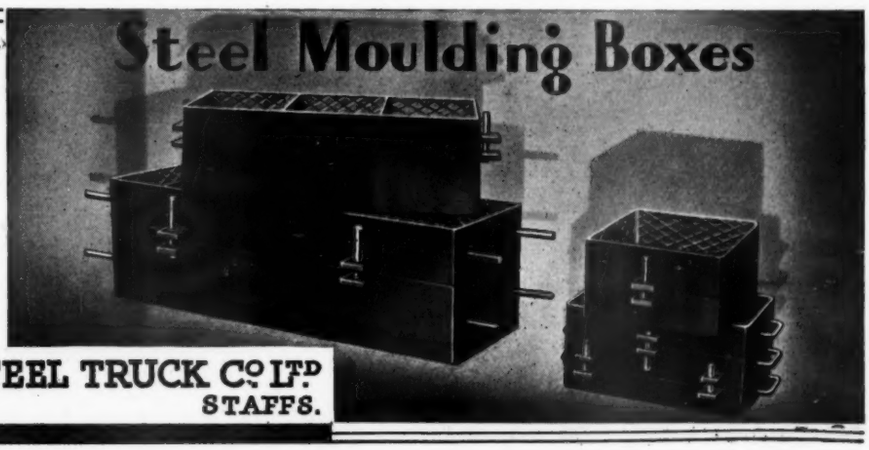

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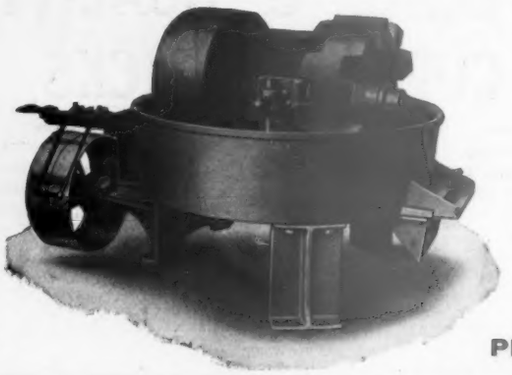

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EXTENSIVELY USED BY COLLIERIES, FOUNDRIES, and IRONWORKS

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NEILD SAFETY FIRST BOOTS

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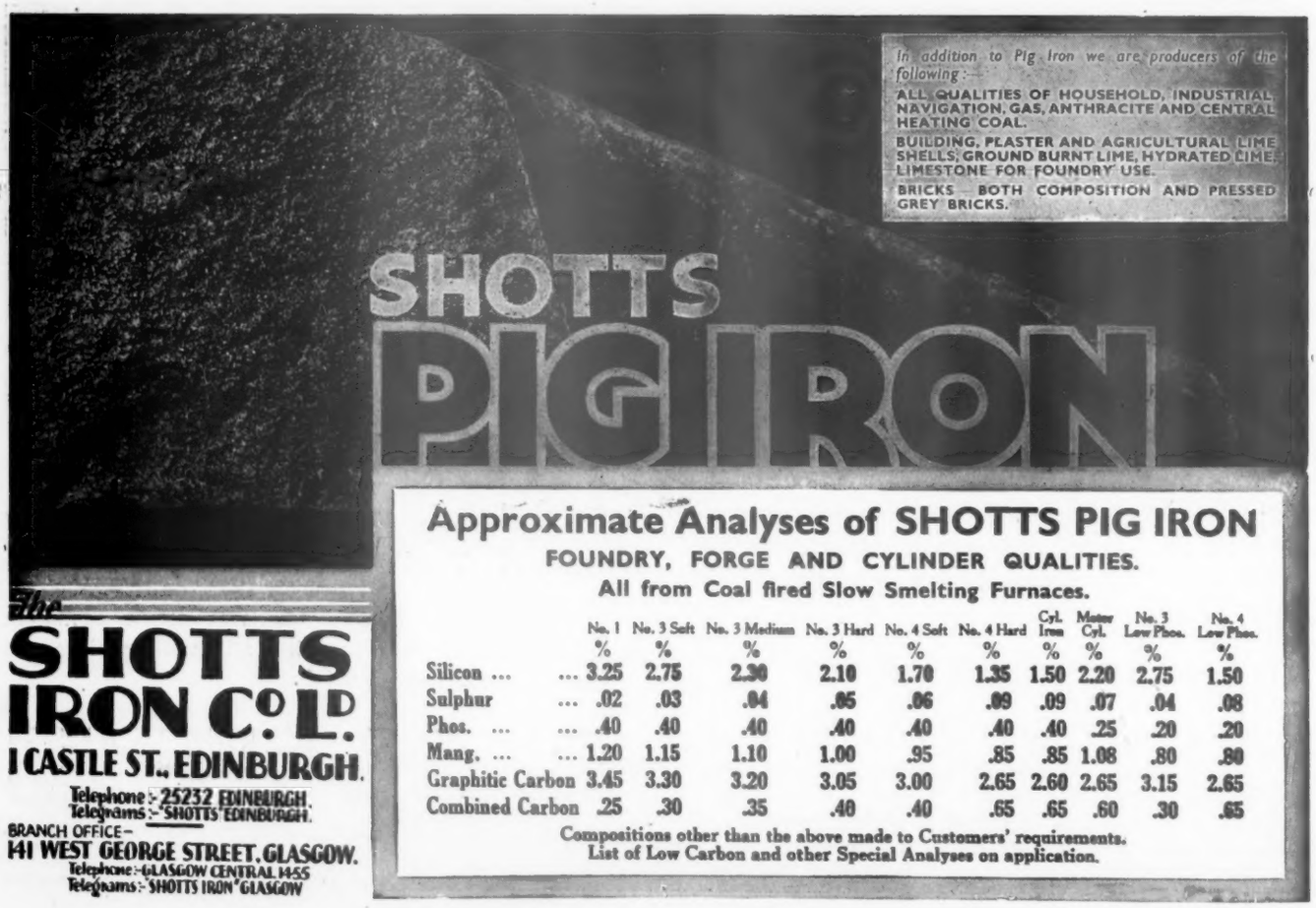
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BRICKS — BOTH COMPOSITION AND PRESSED GREY BRICKS.
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PIG IRON

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FOUNDRY, FORGE AND CYLINDER QUALITIES.

All from Coal fired Slow Smelting Furnaces.

	No. 1	No. 3 Soft	No. 3 Medium	No. 3 Hard	No. 4 Soft	No. 4 Hard	Cyl. Iron	Mottled Cyl.	No. 3 Low Phos.	No. 4 Low Phos.
	%	%	%	%	%	%	%	%	%	%
Silicon ...	3.25	2.75	2.30	2.10	1.70	1.35	1.50	2.20	2.75	1.50
Sulphur ...	.02	.03	.04	.05	.06	.09	.09	.07	.04	.08
Phos. ...	.40	.40	.40	.40	.40	.40	.40	.25	.20	.20
Mang. ...	1.20	1.15	1.10	1.00	.95	.85	.85	1.08	.80	.80
Graphitic Carbon	3.45	3.30	3.20	3.05	3.00	2.65	2.60	2.65	3.15	2.65
Combined Carbon	.25	.30	.35	.40	.40	.65	.65	.60	.30	.65

Compositions other than the above made to Customers' requirements.
List of Low Carbon and other Special Analyses on application.

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